SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

FEBRUARY 1898.

GENERAL PHYSICS.

105. *Atomic Hypothesis.* **L. Boltzmann.** (Annal. Phys. Chem. 61. 4. pp. 790–793, 1897.)—This is a reply to Volkmann's arguments concerning the respective value of the atomistic conceptions and differential equations. Boltzmann maintains that the foundations of the latter method are themselves atomistic, inasmuch as the division of space into space elements, however much reduced in size, involves the idea of discrete entities. An infinite subdivision is mathematically valueless. He illustrates his arguments by reference to Fourier's theory of thermal conduction. E. E. F.

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106. *Viscosity in an Electric Field.* **G. Quincke.** (Annal. Phys. Chem. 62 1. pp. 1–13, 1897.)—The author has succeeded in demonstrating an increase of viscosity experienced by dielectric liquids in an electric field. Spheres of crown and flint glass, quartz, and calcspar, 1 cm. in diameter, were suspended by thin silk fibres attached to the arm of a balance. They were immersed in a small trough containing ether, carbon bisulphide, turpentine, benzol, or various mixtures, and surrounded on two sides by condenser-plates 5 cm. square. The logarithmic decrement of the balance was observed with and without a field due to 2000 volts. The difference was the electric viscosity normal to the lines of force. This viscosity was 0·0398 in the case of a crown glass sphere in ether, being the difference between 0·0210 and 0·0608. The mean value for CS_2 was 0·0309, and for benzol 0·0256. Parallel to the lines of force the viscosity also increases, but to a much slighter extent. In both cases the electric damping is nearly proportional to the difference of potential and the dielectric constant of the liquid. E. E. F.

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107. *Action at a Distance.* **P. Drude.** (Annal. Phys. Chem. 62. 1. pp. 1–49, 1897.)—The author attempts a strict definition of action at a distance, and discusses the reduction of such action to contact-actions and *vice versa.* He compares the properties of electromagnetic and of gravitational effects and investigates the numerical and formal validity of Newton's law. Finally, he summarises the explanations of gravitational attraction hitherto attempted under the two heads of pressure and impact theories. As regards definitions, if the action is purely mechanical, the condition of distance action is that the energy of a system of material bodies depends not only upon their velocities, but also upon their mutual position; or that relative-position quantities between distinct points of space enter into the energy formula. If electromagnetic and radiation effects are to be included, action at a distance must be defined as taking place when the presence or change of state of a body A produces a change of state in another body B, which would not take place if A were absent or underwent no change of state. Contact-action may take place either through elastic solids or by impact, or by transmission through a compressible or incompressible fluid. The phenomena of electricity and magnetism have been reduced to events in the luminiferous ether, but gravitation remains as an unexplained distance action, chiefly owing to the fact that no propagation of gravitational energy in time has yet been proved. Such a proof is rendered very difficult by the circumstance that gravitational attraction cannot be stopped or brought into play at will. Laplace calculated a minimum value for the rate of propagation from the "aberration" due to the motion of the moon, resulting in a velocity 10 million times that of light. Such an aberration would suffice to explain the irregularities in the motion of Mercury and in Encke's and Winnecke's comets. The same object would be gained by altering the inverse square index from 2 to 2·00000016. The impact theories after Le Sage are so far the only half-way satisfactory solutions. According to Preston's modification, no attraction would be exerted beyond the mean free path of the ether molecules, however large the masses of the bodies. E. E. F.

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108. *Influence of Tension on Torsion.* **M. Cantone** and **E. Michelucci.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 191–198, 1897.)—The authors review a paper on "The Influence of Stress or Strain on the Action of Physical Forces," by Tomlinson, and, considering his experiments as not exhaustive, determine to repeat them with such precautions as they deem necessary, so as to find out if an influence of a similar nature to that found by Tomlinson for permanent torsions could be observed in the case of temporary torsions. The apparatus they use for these experiments is the same as that which was used for magnetic experiments on nickel wire, with the difference that the stretching weights, in order to avoid vibrations which might vitiate the results, are obtained by

two vessels placed horizontally, one fixed and the other suspended by the wire, and communicating by a siphon; on causing a difference in level of the water in the fixed vessel by means of a third movable reservoir connected with it by flexible piping, a gradual increase or decrease of weight is produced in the suspended vessel with a minimum of vibrations. The samples consist of wires of annealed iron, nickel, brass, copper, and silver, and of unannealed copper and silver, 35 cm. long by 2 mm. diam.

The conclusion is that no laws can be formulated, as each metal has a behaviour of its own. When a wire subjected to a torsional couple is loaded, in general the angle of twist increases; but the variation, although consistent, is no simple function of the load. Nevertheless, one can say that, in general, with malleable metals the variation is greater than with the less malleable ones. Nickel presents unique characteristics. Its angle of twist diminishes with increase of load, and *vice versa*. Whereas *un*loaded wire generally shortens with increase of torsion, nickel lengthens. These facts are interesting as exhibiting a connection between the magnetic and elastic behaviour of metals.

In conclusion the authors say that "Tomlinson thought he had found in his investigations a variety of effects which, according to our results, are not characteristic of each substance taken separately, but rather depend on the processes of deformation experienced by the substance. Only one substantial irregularity exists, to our mind, among the bodies examined; and that is the anomalous behaviour of nickel above mentioned." A. Gs.

109. *Photographic Determination of the Altitude of Balloons.* **L. Cailletet.** (Comptes Rendus, 125. pp. 587–589, 1897.)—Following Cailletet's suggestion, Gaumont has constructed a camera which is suspended from the balloon so as always to hang vertically, and which takes a photograph of the earth below. There are two lenses in the prismatic wooden box; the one below for the purpose mentioned, the other for photographing the needle of the barometer. Between the two moves a strip of sensitised celluloid. The screens are removed by clockwork every two minutes, when the earth's surface and the needle are photographed on the two sides of the celluloid. From the focal distance and the measured distances on the negative between two known objects below, the elevation of the balloon at that moment can be derived within 1 in 500. After experiments on the Eiffel Tower, Hermite and Besançon took the camera up on October 25 at noon in their new silk balloon of 1700 cub. metres, presented by Balaschow. The ascent from the Villette gas-works near Paris lasted four hours, an altitude of 2500 metres being reached. In spite of the boisterous weather 26 good negatives, 13 × 18 cm., were obtained; the needle of the aneroid was well in the centre of the negative. No particulars are given. H. B

110. *Determination of the Vertical.* **J. Perchot** and **W. Ebert.** (Comptes Rendus, 125. pp. 1009–1012, 1897.)—The usual nadir determination, coincidence between the micrometer-thread and its image reflected from a mercury-bath, is often difficult at Paris owing to oscillations. There is less trouble with a very thin layer of mercury; but errors might arise from capillary effects. Deichmüller has proposed zenith mirrors floating on mercury. This paper describes tests of such a mirror constructed by Gauthier for Loewy. The mirror, silvered underneath, is fixed on a float resting on an annular mercury trough, held by a lever, pivoted in the pillar with a counterweight at the other end. The float is arrested by means of a hook and four notches at quadrantal points. Three adjustment screws had to be added as the mirror did not come back exactly to its original position after making several turns; correct focussing was obtained by means of proper illumination. Details are to be published in the 'Annales de l'Observatoire.' H. B.

LIGHT.

111. *Photographic Photometry.* **H. T. Simon.** (Ast. Phys. Journ. 5. p. 69, 1897.)—The author uses a spectrometer with a quartz-train for ensuring homogeneity and equality of wave-length of the lights to be compared. One half of a photographic plate is exposed to the standard light at the same time that the other half is being exposed to the unknown light. The plate being put in motion, the intensity of the unknown light is gradually reduced by means of rotating sectors. On development, we have one half the plate uniformly tinted and the remaining half uniformly gradated. The point where there is equality in the two densities is read off, and then, by determining to what degree the unknown light has been weakened at this point, its value in terms of the standard is directly obtainable. C. P. B

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112. *Arc Spectra.* **A. L. Foley.** (Phys. Rev. 5. pp. 129–151, 1897.)—A continuation and review of the work of Lockyer in 1879 (Proc. Roy. Soc. 18. p. 425), Gouy (Phil. Mag. 3. p. 238, 1879), and Miss C. W. Baldwin (Phys. Rev. 3. pp. 370–448, 1896), on the spectra of the different regions of the electric arc. The three sheaths of colour are described and illustrated, as well as the Rowland grating and photographic arrangements used in the present research. These latter are very ingenious. Four conditions were studied: (1) vertical arc and vertical slit, (2) vertical arc blown out by a horse-shoe magnet, (3) horizontal arc and vertical slit, (4) arc and slit both horizontal. Elaborate tables are given of the lines with and without the presence of different elements. The much disputed spectrum of carbon is specially examined. S. G. R.

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113. *Elastic Bodies and Light.* **P. Glan.** (Annal. Phys. Chem. 60. 1. pp. 174–192, and 60. 3. pp. 563–576, 1897.)—Parts 11 and 12 of this paper deal with the equations of elasticity in crystals, and circularly polarised oscillations in crystals, the investigations being of a highly mathematical character. The vibrations discussed in the second paper are found to be connected with double refraction in crystals in accordance with the laws of double refraction of light. G. H. Br.

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114. *Maxwell's Constants for Beech-wood.* **D. Mazzotto.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 95–100, 1897.)—In accordance with Maxwell's relation $n = \sqrt{K}$, to the two different values of the principal indices of refraction in wood correspond two different dielectric constants; and the differences between the two values

of the refractive index in senses perpendicular and parallel to the fibre coincide appreciably with the differences between the corresponding values of $\sqrt{K}$. As the wood becomes dry the two dielectric constants become much smaller, and, in harmony with the above-mentioned relation, the indices of refraction also fall off; the differences between the new values of the refractive index still remain equal to the differences between the respective values of $\sqrt{K}$, but are considerably less than those presented by wood in the natural state. A. D.

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115. *The Faraday and Zeeman Effects.* **H. Becquerel.** (Comptes Rendus, 125. pp. 679–685, 1897.)—An essential difference exists between the phenomenon of magnetic rotatory polarisation discovered by Faraday and the effect discovered by Zeeman, which latter consists in a change of the period of a luminous source placed in a magnetic field; no such modification having been observed in the case of the phenomenon of Faraday. Magnetic rotatory polarisation corresponds to a variation in the velocity of propagation of circularly-polarised light. In 1885 the author calculated the velocity of rotation of a vortex motion of the ether, to which the observed phenomena could be attributed; and there is an interesting agreement between the number then indicated and that which can be deduced from the experiment of Zeeman. The author examines the hypothesis which attributes to the ether in a magnetic field equal to unity (C.G.S.) a vortex motion of period θ, and investigates the consequences of this hypothesis in the case of the phenomenon of Zeeman and of magnetic rotatory polarisation.

1. *Zeeman's phenomenon.*—Zeeman has observed that when the spectrum of a sodium-flame placed between the poles of an electromagnet is examined, each of the rays D_1 and D_2 is transformed into a triplet when viewed in a direction perpendicular to the lines of force of the magnetic field, and into a doublet when the flame is looked at in a direction parallel to the lines of force. Considering the last case only: the two components of the doublet are circularly polarised in contrary directions. Moreover, experiment proves that the circular motion whose period is the shorter has the same direction as the current of a solenoid equivalent to the magnetic field. If a magnetic field be considered as a space animated with vortex motions whose axes are parallel to the lines of force, it is possible to examine the consequences of the hypothesis which supposes that this motion is added to the circular motions of one of the two beams into which a beam of natural light can be decomposed, and that it is subtracted from the motions of the other.

Let θ be the period of the vortex motion of the field, N the number of rotations per second of the luminous circular motion outside the magnetic field, the number of rotations will become $N'=N+\frac{1}{\theta}$ for the luminous circular motion of the same sense as the vortices, and $N''=N-\frac{1}{\theta}$ for the inverse motion. The wave lengths λ' and λ'' of the two circular beams will be different, and denoting by V_0 the velocity of light *in vacuo*,

$$N\lambda = V_0, \quad \text{and} \quad \frac{dN}{N}+\frac{d\lambda}{\lambda}=0,$$

hence

$$-\frac{\Delta\lambda}{\lambda}=\frac{N'-N''}{N}=\frac{2\lambda}{V_0\theta}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The variation of wave-length $\Delta\lambda$ should be proportional to the square of the wave-length.

Zeeman has found by experiment $\frac{\Delta\lambda}{\lambda}=\frac{1}{40000}$ for the ray D_1 and a magnetic field equal to 10^4 (C.G.S.); hence for this field $\frac{1}{\theta_1}=6{\cdot}36\times10^9$. If it is supposed that the rapidity of the vortex motion increases proportionally to the intensity of the field, then, for a magnetic field equal to unity C.G.S.,

$$\frac{1}{\theta}=6{\cdot}36\times10^5 \text{ rotations per second.}$$

It is very remarkable that the phenomenon of magnetic rotatory polarisation leads to the same numerical value.

2. *Faraday's phenomenon.*—Fresnel's theory of ordinary rotatory polarisation may be applied to magnetic rotatory polarisation, and the rotation of the plane of polarisation may be considered as due to the different retardations, in crossing a substance placed in a magnetic field, undergone by the two inverse circular rays whose superposition is equivalent to a wave rectilinearly polarised. Let ω be the rotation of the plane of polarisation, e the thickness of the body traversed, V' and V'' the velocities of propagation of the two circular rays, and T their common period, then

$$\frac{\omega}{\pi e}=\frac{1}{T}\left(\frac{1}{V'}-\frac{1}{V''}\right)=\frac{n'-n''}{\lambda} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The rotation takes place in the direction of the motion of the circular ray which has the greater velocity of propagation.

According to an hypothesis of the author, a circular vibration rotating in the same sense as the medium will behave as if its wave-length was increased: it will then be propagated more rapidly, and the plane of polarisation of a polarised beam will rotate in the sense of the vortex motion of the magnetic field. This view is supported by the results of experiment in the case of the two phenomena considered. The numerical agreement is also satisfactory. Let θ be the period of the vortex motion of the field, N the number of vibrations per second common to two rays circularly polarised in inverse senses. According to the hypothesis, these two rays will behave as if their numbers of vibrations were $N'=N-\frac{1}{\theta}$ and $N''=N+\frac{1}{\theta}$; to these numbers N' and N'' correspond wave-lengths

λ' and λ'' and indices of refraction n' and n''. The dispersion-formula of the medium considered gives

$$n'=n+(\lambda'-\lambda)\left(\frac{dn}{d\lambda}\right), \quad n''=n+(\lambda''-\lambda)\left(\frac{dn}{d\lambda}\right),$$

besides

$$\frac{\lambda'-\lambda''}{\lambda}=\frac{N''-N'}{N}=\frac{2\lambda}{V_0\theta}, \text{ and } \frac{n'-n''}{\lambda}=\frac{\lambda'-\lambda''}{\lambda}\left(\frac{dn}{d\lambda}\right)=\frac{2}{V_0\theta}\lambda\left(\frac{dn}{d\lambda}\right).$$

Substituting this value in formula (2) it becomes

$$\frac{\omega}{2\pi e}=\frac{1}{V_0\theta}\lambda\left(\frac{dn}{d\lambda}\right). \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

In order to approach the conditions of Zeeman's experiment, let $\frac{\omega}{2\pi e}$ be calculated for air. The author formerly found for the magnetic rotation $\frac{\omega}{e}$ of bisulphide of carbon in unit magnetic field (C.G.S.) the number 0·0434 relative to the ray D, and on the other hand he had obtained for the magnetic rotatory power of air, referred to bisulphide of carbon and the ray D, the number 0·000159. Taking $V_0=3\times10^{10}$, then $\frac{\omega}{2\pi e}V_0=9{\cdot}586$. Mascart's experiments on the dispersion of gases lead, for air, to the value $\lambda\frac{dn}{d\lambda}=1{\cdot}443\times10^{-5}$ for the ray D. On putting these values into formula (3),

$$\frac{1}{\theta}=6{\cdot}64\times10^5,$$

a number very near that to which Zeeman's phenomenon leads.

Thus the hypothesis of a vortex motion of the ether in a magnetic field does not appear to be contrary to experiment, and connects together phenomena which are both of them manifestations of the action of a magnetic field on the luminiferous ether. In the case of Zeeman's phenomenon new determinations are necessary to verify if the variation of wave-length is, as the hypothesis indicates, proportional to the square of the wave-length and to the intensity of the magnetic field. J. J. S.

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116. *Zeeman Effect.* **A. Cotton.** (Comptes Rendus, 125. pp. 865–867, 1897.)—The change of the vibratory period of sodium light discovered by Zeeman can be proved very easily by a simple method which does not require any dispersive apparatus. Sodium flames are enveloped by a hot but non-luminous sheath containing sodium. If a flame A be observed when it is placed in front of another B, suitably chosen, the gaseous envelope being absorbent, the edges of the flame A appear black. For example, the flame of a spirit-lamp containing sodium may be taken for A,

and the flame of a Bunsen burner containing a salt of sodium for B. The exterior envelope of the flame absorbs the radiations of sodium light, but it presents in this region of the spectrum only two very narrow absorption-bands. This property is due to the low density of the sodium vapour, and to the value of the temperature in that part of the flame. These absorption-bands are sufficiently narrow to allow the very feeble change of vibratory period of the flame B produced by the magnetic field to suppress the absorption, and to cause the disappearance of the black border of the flame A. By suitable arrangements of the flames with regard to the poles of an electromagnet, observations may be made in directions parallel and perpendicular to the lines of force. J. J. S.

117. *Zeeman Effect.* **A. Cornu.** (Écl. Électr. 14. pp. 185–190, 1898.)—Observations with improved apparatus of high dispersive power show that the central line of the Zeeman triplet is really double; the clearness of definition excluding the hypothesis of reversal. It is inferred that the component vibration parallel to the lines of force is doubled, the periods of the two parts being respectively increased and diminished by the same amount, this amount being proportional to the intensity of the field. Micrometric measurements lead to the conclusion that the effect of the field in producing changes of period depends not only on the chemical nature of the source of light, but also on the nature of the group of spectral lines to which each particular radiation belongs, and the part which it plays in this group. Thus the magnesium group *b* and the zinc group of three blue rays show a rapid increase of the magnetic doubling effect with increase of refrangibility, although the change of wave-length is insignificant. The ray most easily reversible shows the least amount of separation in the doublet. Similarly, the sodium lines D_1 and D_2 give strikingly different effects. To avoid astigmatism, a plane Rowland's grating is used; and the arrangement is such that the micrometer eyepiece is simultaneously in adjustment for all the rays of the spectrum. G. B. M.

118. *Persistence of Period in the Faraday Effect.* **A. Broca.** (Journ. de Physique, 6. pp. 678–681, 1897.)—Experiments made (1) with Thoulet's liquid and a Rowland grating, (2) with transparent iron electrolytically deposited on platinised glass, show no alteration of period. If any part of the rotation is due to change of period, it must be less than 1/4000 of the total effect. G. B. M.

119. *Mechanism of the Rotatory Polarisation of Light in a Magnetic Field.* **A. Broca.** (Comptes Rendus, 125. pp. 696–699, 1897.)—The author describes certain experiments which he made in order to prove rigorously that no change of period takes place as a ray of light traverses the magnetic field. It appeared from

Cornu's investigations concerning the Zeeman phenomenon, that for the production of that effect it is necessary that the source of light should itself be in the magnetised field. Experiments made to discover whether an effect of the same order would be produced by the mere transmission of the ray gave a negative result. This had been previously proved by Tait. These experiments were based on Maxwell's conception of rotatory polarisation, according to which there is no modification of energy as the ray passes. It remains to see whether this would be the case if there be a modification. A change of period would take place by the advance or retardation of a molecule of ether in the trajectory. His experiments disclose no change of period. Experiments made by Cotton and Righi had shown before that there is no absorption nor increase of energy in the magnetic field, with the exception, perhaps, of the case of iron. M. Broca's results show that even in that case, if there be absorption, it takes place without change of period. S. H. B.

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120. *Transmission of Energy and Rotatory Polarisation.* **A. Broca.** (Comptes Rendus, 125. pp. 765-767, 1897.)—In this paper M. Broca proposes to find the characteristic of those parts of a medium where the forces to which the transmission of energy is due have a potential, and those parts where they have not. He proves three theorems.

Theorem I. Let ρ be the quantity of energy per unit of volume, E the flux of energy, $\lambda\ \mu\ \nu$ its components, A the quantity transformed per unit of volume. Then, *Theorem* I.: In the permanent state the vector E is irreversible or reversible, according as there is or is not transformation at the point considered. For simple hydrodynamical considerations give

$$\frac{d\rho}{dt}+\left(\frac{d\lambda}{dx}+\frac{d\mu}{dy}+\frac{d\nu}{dz}\right)+\mathrm{A}=0.$$

If the flux is reversible, the second member may have its sign changed. But if $\frac{d\rho}{dt}=0$, which is the permanent state, this requires that $\mathrm{A}=0$.

Theorem II. The sufficient and necessary condition that a force shall be derived from a potential is that the axes of the ellipsoid of variation of the force coincide with the corresponding directions. In other words, there is symmetric equality.

Theorem III. The sufficient and necessary condition that a force shall not be derived from a potential is that there be transformation of energy at the point considered.

The above considerations show, he says, *à priori* that the rotatory polarisation cannot arise from Zeeman's phenomenon except in absorbent media. The magnetic field itself is a reversible phenomenon, and so, in the absence of absorption, is the ray of light. But if the medium be absorbent, we should expect to find, if circularly-polarised light and the magnetic field are the same in kind, absence of symmetric equality and transformation of energy. He explains why this had not been observed by Cotton as due to the feebleness of the effect in his experiments. And with regard to the Zeeman phenomenon itself, he points out that we cannot make a circuit in one direction without one in the opposite direction in its neighbourhood, which, if the two are of equal intensity, reduce the magnetic field to one of simple orientation. The magnetic field in the flame may be derived from a potential. But owing to the fact that transformation of energy is going on in the flame, this cannot be concluded with certainty. S. H. B.

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121. *Rapid Exposures in Radiography.* **G. Séguy.** (Comptes Rendus, 125. p. 602, 1897.)—Coat a thin glass plate with bromide emulsion on both sides. Make two flexible screens of linen with Becquerel's violet sulphide of calcium suspended in celluloid. Put one of these screens on each side of the coated glass plate, and back both with black card. Put in a frame under pressure. This gives the thorax very clearly in 30 seconds, and other exposures may even be instantaneous. A. D.

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122. *New Bianodic Bulb with Red Phosphorescence.* **G. Séguy** and **E. Gundelag.** (Comptes Rendus, 125. pp. 602–603, 1897.)—By incorporating with colourless transparent and non-fluorescent glass some albumen in powder and some carbonate of lime or, better, chloride of didymium, a bulb is made which gives, not green, but red fluorescence, which emits twice the Röntgen radiation, and which excites in the screen a brighter fluorescence of a yellowish-green mixed with red. A. D.

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123. *Röntgen Rays and Cutaneous Evaporation.* **L. Lecercle.** (Comptes Rendus, 125. pp. 613–614, 1897.)—Röntgen rays inhibit cutaneous evaporation in the hind quarters of a rabbit. This may go on to complete suppression, and the effect lasts for a long time. In the palm of the human hand the effect is similar, but is smaller and transitory. A. D.

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124. *Dissemination of Röntgen Rays.* **A. Buguet.** (Comptes Rendus, 125. pp. 702–703, 1897.)—Backing the photographic plate with lead makes the details of opaque objects very much clearer. The explanation is that the lead prevents the return of radiations which fog the plate. Protecting the sides of the opaque object by a lead cylinder also hinders radiations scattered through the air from depreciating the sharpness of the margins of the silhouettes obtained. Examples are shown of radiographs of a watch and of a Lebel gun without and with these protections. The time of exposure is materially shortened. A. D.

125. *Entoscope for Röntgen Experiments.* **E. Ducretet.** (Paris. Soc. Franç. Phys., Bull. 103. p. 3, 1897.)—A short account is given of a Rhmukorff coil, with a mercury interrupter. The author finds that interrupters with solid platinum contacts are inferior to mercury interrupters for Röntgen work. Mention is also made of the entoscope, an instrument proposed by Ducretet in April 1896, and simultaneously by Edison. It is a dark box with holes for the eyes, containing at the other end a fluorescent screen for receiving Röntgen rays. Its object at first was to facilitate Röntgen work in daylight. R. A.

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126. *Propagation of Röntgen Rays.* **G. Sagnac.** (Écl. Élect. 13. pp. 531–539, 1897.)—As yet, the hypothesis that Röntgen rays are ultra-violet radiations meets all the facts. Taking a fairly broad slit as a source, then bringing rays through a fairly fine slit parallel to this, camera-obscura fashion, and then through a fine platinum-wire gauze, and on to a photographic plate: with light, the image of the object is broadened (diffraction); but with Röntgen rays it is not appreciably so, or at any rate not more than would correspond to a wave-length $\frac{1}{14}$ that of light, taking line D or say 0·01 μ. Gouy's work with focus-tubes as sources brings this down to below 0·005 μ. This applies to the particular tubes used, and to transmission through 5 m. of air and through wood. But the absorption by air is extreme: $\frac{1}{10}$ mm. of air extinguishes ultra-violet rays of wave-length 0·1 μ (Schumann); and it may be that the air absorbs those components of the Röntgen radiations which might have shown diffraction phenomena. The scattering of Röntgen rays by air through which they pass is a phenomenon of a different order, analogous to fluorescence or to the scattering of light by tobacco-smoke, much more probably the former. Apparent phenomena of diffraction, observed by several, are really penumbra effects. Mr. Wind has suggested a secondary diffraction; but this, when tested numerically, gives a result much smaller than that observed with Röntgen rays; and the apparent diffraction can be explained as due to phenomena of photographic reversal. The author finds, when precautions are taken to avoid accidental differences, no trace of polarisation by absorption, dependent on the orientation of the absorbing medium; neither has he succeeded in obtaining phenomena analogous to circular dichroism. This does not prove the vibrations not to be transverse: it shows that matter and the vibrations do not react in that way. The absence of refraction is apparently complete, slight indications of it being due to want of parallelism of the slits, and disappearing when this is exact. At any rate, the index of refraction differs, for many substances, by less than 0·000001 (Gouy), and even a difference of 0·0002 would make the Röntgen rays have a wave-length $\frac{1}{800}$ that of line D. These small wave-lengths would explain the absence of refraction and of diffraction (Raveau, L'Écl. Élect. t. 6. p. 249). The apparent deviation of

Röntgen rays near conductors is explicable as an exaggerated penumbra effect: the apparent bending behind opaque bodies is explicable as due to the diameter of the source or to the scattering of the rays by air; and Lafay's "magnetic deviation of electrified Röntgen rays" as due to displacements of the kathode rays in an electric or magnetic field, the results alleged being also denied by Profs. Lodge and Silvanus Thompson. Prof. Stokes has shown the alleged deviation of Röntgen rays by the magnet to be a misinterpretation. No effect of Röntgen rays upon the transmission of light in a vacuum has ever been shown. The only positive fact bearing upon the nature of Röntgen rays, in their propagation, is the ease with which they are scattered by diverse media; and future enquiry will have to be in this direction, since ordinary optical tests are impossible on account of the smallness of the wave-length. A. D.

127. *Heating Effects of Röntgen Rays.* **E. Dorn.** (Annal. Phys. Chem. 63. pp. 160–176, 1897.)—That the X-rays exert a definite heating effect was already assumed by their discoverer. The effect may be definitely proved by exposing suitable metallic sheets to the radiation in a vessel communicating with a Toepler pressure-gauge, which shows an increase of pressure due to the heating of the sheets and expansion of the gas. That this expansion is not due to dissociation may be proved by reference to the amount of electricity disengaged, according to which the fraction of dissociated air in the bulk of the gas is of the order 10^{-12}, *i. e.* quite inappreciable. Besides, the same increase of pressure may be brought about by the artificial heating of the same metallic sheets, which also enables the observer to accurately determine the amount of the heating effect. The author carried out a series of experiments on this principle, using platinum or palladium sheets mounted at intervals along a cylindrical vessel connected with the pressure-gauge. With 9 accumulators and a sparking-distance of 83 mm., the heat radiated per second was 1·68 mgr.-calories—a very small value in comparison with kathode rays. That the heat was not produced by induced currents in the sheets was proved by interposing a glass plate, which, by absorbing the X-rays, reduced the heating to $\frac{1}{4}$ of its value. E. E. F.

HEAT.

128. *Critical Temperatures and Pressures.* **A. Leduc** and **P. Sacerdote.** (Comptes Rendus, 125. pp. 397–398, 1897.)—The authors find :—For HCl, 52° and 83 atm. (51° and 96, Vincent & Chappuis; 52°·3 and 86, Dewar); for PH_3, 52°·8 and 64 atm.; for H_2S, 100° and 90 atm. (100° and 88·7, Olszewski; 100°·2 and 92, Dewar). A. D.

129. *Specific Heat of Gases. Fourth Memoir: Part I.* **S. Lussana.** (N. Cimento, 4. 6. pp. 81–93, 1897.)—The author advances the view, based upon experimental evidence described in this paper, that the specific heat of atmospheric air at constant pressure, referred to the unit of mass, depends even for low pressures on the density. This is certainly the case for other gases as well; for carbonic anhydride the coefficient of variation with the pressure, determined by the author, is fully confirmed by the researches of Amagat. This result differs from Regnault's well-known law, according to which the specific heat of atmospheric air per unit mass is independent of the density; and the author carefully points out the points of difference between his experiments and those of Regnault. G. H. Br.

130. *Superfusion and Freezing-Points of Solutions.* **F. M. Raoult.** (Comptes Rendus, 125. pp. 751–755, 1897.)—The true depression of freezing-point C of a solution, and the depression C′, observed with a superfusion S, are related by the expression

$$C = C'(1-KS),$$

where K depends on the apparatus and mode of observation. The author's previous experiments (Phys. Soc. Abstracts, No. 309, June 1897) gave variable values for K. The present observations, however, made by the same method, show that K is practically constant, its mean value differing little from that calculated by means of an expression formerly given by the author (Revue Scientifique, 1886, p. 683), which takes into account the heat evolved by separation of ice and the loss or gain of heat to or from external sources. The inconstant values of K formerly obtained are attributed to some deviation of the actual conditions of experiment from those assumed in the theoretical equation.

The results communicated in the present paper are as follows:—The molecular depression of freezing-point of potassium chloride increases rather rapidly with diminishing concentration of the solutions, tending toward the limit 36·4 at infinite dilution. For cane-sugar the molecular depression decreases somewhat with decreasing concentration, the limit being 18·72. The author thinks that it is now definitely proved that the limiting values for the two substances examined are in complete accordance with the theory of Arrhenius. T. E.

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131. *Second Differential Coefficients of Gibbs' Function Zeta.* **W. L. Miller.** (Journ. Phys. Chem. 1. pp. 633-642, 1897.)—In his paper on "Heterogeneous Systems" Prof. Gibbs introduced the function

$$\zeta = \epsilon - t\eta + pv,$$

where

$$d\zeta = -\eta dt + vdp + \Sigma\, \mu dm;$$

and the condition that $d\zeta$ should be a perfect differential involves, among others, the relation

$$\frac{\partial\mu_1}{\partial m_2} = \frac{\partial\mu_2}{\partial m_1}.$$

The object of the present paper is to illustrate the importance of this relation for the theory of ternary mixtures, which the author treats under the following heads:—Interpretation of μ; μ as a function of solubility; solubility and electromotive force; freezing-points of ternary mixtures; their vapour-tensions, and their boiling-points. G. H. Br.

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132. *Variation of Energy in Isothermal Transformations.* **H. Pellat.** (Comptes Rendus, 125. pp. 699-702, 1897.)—M. Pellat points out that an error is usually made in calculating the quantity of energy which has to be imparted to a system to maintain its temperature constant. Generally, if T denote temperature, and W external work done, we have two equations of the form

$$dQ = a\, dT + b\, dx,$$
$$dW = h\, dt + k\, dx.$$

If U be energy and S entropy, we have

$$dU = J\, dQ - dW = (Ja - h)\, dT + (Jb - k)\, dx,$$
$$dS = \frac{dQ}{T} \qquad = \frac{a}{T} dT + \frac{b}{T} dx,$$

whence, assuming U and S to be complete differentials, we find

$$b = \frac{T}{J}\left(\frac{dk}{dT} - \frac{dh}{dx}\right).$$

If then dU_T denote the variation of energy of the system in an isothermal transformation,

$$dU_T = (Jb - k)\,dx = \left[\mathrm{T}\left(\frac{dk}{d\mathrm{T}} - \frac{dh}{dx}\right) - k\right] dx;$$

and not, as usually given,

$$dU_T = -k\,dx.$$

It is usual to neglect b or $\mathrm{T}\left(\frac{dk}{d\mathrm{T}} - \frac{dh}{dx}\right)$, which, however, is not zero unless $d\mathrm{W}$ is a complete differential, which is exceptional. M. Pellat gives an example. A condenser consists of two metal plates; M is the absolute charge on either, V the potential, C the capacity. We have then for the work done, if the absolute charge is increased by dM,

$$-d\mathrm{W} = \mathrm{V}d\mathrm{M} = \frac{\mathrm{M}}{\mathrm{C}}\,d\mathrm{M}.$$

And to maintain the temperature constant during this increase of charge, we have to furnish a quantity of heat equal to $b\,d\mathrm{M}$.

If with constant charge we increase the temperature by dT, we require a quantity of heat $a\,d\mathrm{T}$. In the whole, therefore, if both processes take place the heat required is

$$dQ = a\,d\mathrm{T} + b\,d\mathrm{M},$$

while the work done is $-\frac{\mathrm{M}}{\mathrm{C}}\,d\mathrm{M}$.

Comparing this with the general equations, we have

$$x = \mathrm{M}, \qquad h = 0, \qquad k = -\frac{\mathrm{M}}{\mathrm{C}};$$

and therefore

$$dU_T = \left(\mathrm{T}\frac{\mathrm{M}}{\mathrm{C}^2}\frac{d\mathrm{C}}{d\mathrm{T}} + \frac{\mathrm{M}}{\mathrm{C}}\right) d\mathrm{M} = \frac{1}{\mathrm{C}}\left(1 + \frac{\mathrm{T}}{\mathrm{C}}\frac{d\mathrm{C}}{d\mathrm{T}}\right) \mathrm{M}\,d\mathrm{M}.$$

Therefore, as the charge increases from zero to M, the heat to be supplied is

$$\Delta U_T = \frac{1}{\mathrm{C}}\left(1 + \frac{\mathrm{T}}{\mathrm{C}}\frac{d\mathrm{C}}{d\mathrm{T}}\right)\frac{\mathrm{M}^2}{2}$$

$$= \tfrac{1}{2}\mathrm{MU}\left(1 + \frac{\mathrm{T}}{\mathrm{C}}\frac{d\mathrm{C}}{d\mathrm{T}}\right)$$

(assuming C to be independent of M),

instead of $\frac{1}{2}$MV, as usually given. C varies with the temperature, as it alters the size of the plates. S. H. B.

133. *Thermodynamics of Luminescence.* **K. Wesendonck.** (Annal. Phys. Chem. 62. 4. pp. 706–708, 1897.)—E. Wiedemann has described some cases in which the second law of thermodynamics, precluding the passage of heat from a cold to a hot body, does not apply. A luminescent body, or a flame of 500° made non-luminous by carbonic acid, will further heat a platinum cage which slightly exceeds them in temperature. But these exceptions are only apparent. The conversion of luminous into heat energy has a certain exchange value; and so long as a larger negative exchange value is not proved to exist in the phenomenon of luminescence, the second law cannot be said to be infringed.

E. E. F.

SOUND.

134. *Vibrations of Strings produced by Electric Discharges.* **F. Melde.** (Annal. Phys. Chem. 63. pp. 78–82, 1897.)—The contrivance of bell-ringing by an electric discharge which sets in motion a ball suspended between two bells may be extended to the motion of a metallic string. The string, preferably gold or silver thread, must be insulated at the ends. It is stretched horizontally between the knobs of an influence-machine, or of a battery of Leyden jars. The vibrations are in the natural period, slightly modified by the quantity of electricity passing. By damping at the nodes, the multiple vibrations known to acoustics may be produced. E. E. F.

ELECTRICITY.

135. *Electrodynamical Model.* **A. Garbasso.** (N. Cimento, 4. 6. pp. 260–273, 1897.)—An isolated current without a condenser is represented by rotating a horizontal axis to which are rigidly attached a cross-bar meeting it at right angles and a four-vaned fan. By means of sliding weights acted on by springs the moment of inertia of the system about the axis can be changed, and the vanes of the fans can be turned round the rods to which they are attached, so as to alter the frictional resistance of the air. The analogy of a single conductor with a condenser is obtained by clamping the end of the axis to one end of an elastic wire, stretched horizontally in the same line with the axis and clamped at the other end. The torsional rigidity of the wire corresponds to the capacity of the condenser. The case of two adjacent circuits without a condenser is illustrated by means of two models like that first described, and a connecting mechanism by means of which a rotation communicated to one may be partially transmitted to the other. At one end of the axis of each model is fixed a conical toothed wheel, and these wheels act each on two other similar wheels fitted axially upon a weighted cross-bar. Then, if l_1, l_2 are the moments of inertia of the rotating parts of the models, m that of the intervening mechanism (all with reference to the axis), ω_1, ω_2 the angular velocities of the parts corresponding to l_1 and l_2, the *vis viva* of the whole system is

$$T=\tfrac{1}{2}l_1\omega_1^2+\tfrac{1}{8}m(\omega_1+\omega_2)^2+\tfrac{1}{2}l_2\omega_2^2=\tfrac{1}{2}L_1\omega_1^2+M\omega_1\omega_2+\tfrac{1}{2}L_2\omega_2^2,$$

where $$L_1=l_1+\tfrac{1}{4}m,\quad M=\tfrac{1}{4}m,\quad L_2=l_2+\tfrac{1}{4}m;$$

and this is the characteristic form of T for a dicyclic system. Taking account of the frictional resistance, we obtain the equations of motion

$$E_1=\frac{d}{dt}(L_1\omega_1+M\omega_2)+R_1\omega_1,$$

$$E_2=\frac{d}{dt}(M\omega_1+L_2\omega_2)+R_2\omega_2.$$

By using elastic wires, as before, it is possible to illustrate the case of two circuits, one or each of which is connected with a condenser. G. B. M.

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136. *Poynting's Theorem.* **P. S. Wedell-Wedellsborg.** (Zschr. phys. Chem. 22. pp. 222–224, 1897.)—The object is to prove, with the help of Poynting's Theorem, that Maxwell's equations of the electromagnetic field only hold in free ether, while in the interior of conductors and of molecules they have no meaning. The electric oscillations on a perfect conductor isolated in space

may possibly be unaccompanied by dissipation of radiant energy. This conclusion has an important bearing on Ostwald's theory of the permanence of solar energy. G. H. Br.

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137. *Wimshurst Machines.* **S. M. Keenan.** (Amer. Electn. 9. pp. 316–317, 1897.)—Sectors are not necessary to the working of a Wimshurst machine. When long sparks are required, sectors are somewhat detrimental. Sectorless machines, on the other hand, are not self-exciting, but they can easily be separately excited, and they retain their charge for some time. When the sectors are removed it is necessary to attach several brushes or points to the neutraliser; these and the brushes and points of the collectors should be adjustable. The sectorless machine is said to give a discharge three times greater than a sector machine of similar dimensions, and it will work in all weathers. For Röntgen-ray operations a two-disc sectorless machine is unsuitable; the "current" is said to be too small to excite the Crookes tube. But multiple-plate machines at high speeds answer perfectly for every purpose of experiment and electro-therapeutics with Röntgen-ray apparatus. The writer of the article recommends a 32-inch diameter sectorless machine for this work. The induced charges are made to assume more or less continuous or interrupted oscillation by regulating the sliding discharge-rods. By these, also, the "volume" of the direct discharge may be controlled. They are used in association with a regulated spark-gap in the main circuit of a high-frequency transformer. Such a machine has been in operation with excellent results in the Wayne County Hospital. It produces powerful sparks 15 inches long, described by the author as "absolutely deafening." Nevertheless, patients have been known to recover from its effects. R. A.

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138. *Atmospheric Electricity.* **M. Brillouin.** (Écl. Électr. 13. pp. 577–579, 1897.)—The author seeks to explain the atmospheric electricity by the action of the ultra-violet rays of the sun's light causing the loss of the negative charge produced by induction on needles of ice suspended in the upper strata of the atmosphere when these needles are in an electric field. In support of his theory he has performed some experiments on the loss of electricity of a negatively electrified block of ice, and he finds that so long as the surface of the ice is dry the loss of negative electricity when exposed to ultra-violet light is very rapid. When the surface becomes covered with a film of water, this loss practically stops. The author concludes that the atmospheric electricity is maintained by the action of the ultra-violet rays of the sun on the needles of ice which occur in the cirrus clouds; and that the original charge is produced in the same way, the necessary electrical field to account for the induced charges on the needles being due to the movements of the upper regions of the atmosphere with respect to the magnetised earth. W. W.

139. *Atmospheric Electricity.* **G. Le Cadet.** (Écl. Électr. 13. pp. 579–581, 1897.)—The author, from the results of the measurements he has made on the strength of the electrical field at different altitudes, concludes that the lower strata of the atmosphere contain electrified masses of air of opposite sign, the positive charged air being on the whole in excess, and that this positive excess, together with the negative charge on the surface of the earth, accounts for the production at a height of about 8000 metres of a field of practically zero strength. To explain the electrification of the air, the author makes use of the effect of ultra-violet light on the particles of dust in the air (*cf.* preceding Abstract). W. W.

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140. *Atmospheric Electricity in the Sahara.* **F. de Courmelles.** (Écl. Électr. 13. p. 583, 1897.)—During the occurrence of the sirocco, the manifestations of atmospheric electricity were found very marked. W. W.

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141. *Dielectric Resistance.* **Bates** and **Barnes.** (Amer. Instit. Elect. Engin. 14. pp. 429–438, 1897.)—In May 1896 a paper was read before the American Institute upon the influence of temperature upon dielectric resistance (see Phys. Soc. Abstracts, No. 769, Nov. 1896). Many of the results seemed fortuitous, and it was suggested that the effect of moisture had perhaps been overlooked. The present paper is a discussion of the earlier one. With regard to the use of cellulose as an insulator, **Perrine** points out that it is an undesirable substance; it begins to decompose at moderate temperatures, even below 100° C. Cotton-covered wire turns brown under like conditions, being aged like the paper of old books. **Steinmetz** regards the phenomena observed by the authors in measuring the resistance of dielectrics at various temperatures as being due, (1) to the change of dielectric resistance, (2) to the effect of moisture, (3) to chemical disintegration. [To these should be added the change in contact-resistance between the dielectric and the electrodes—a most important matter, not referred to by the authors.] He objects to specifications which allow baking before the final test on a paper cable. If the dielectric is fibre of bad quality it will be punctured at low voltage, and still after baking test as of high insulation. Fibre of good quality, after long exposure to damp air, may be of relatively low resistance; but nevertheless it will not be punctured at low voltage. He concludes that specifications for this kind of cable should be drawn up on a basis of spark-resisting power rather than upon a given number of megohms. A fibrous material can be baked to the point of rottenness and still retain very high insulation, but it will have small power to resist a spark. R. A.

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142. *Ambroïne.* **J. A. Montpellier.** (Électricien, 15. pp. 17–19, 1898.)—"Ambroïne" is a new insulating material; it was manufactured in the first instance in Germany, but works have

recently been installed for it in France. Resin, mica, and amianth are part of its composition; these are carefully ground and mixed, and are then submitted to chemical treatment. Finally, the mixture is heated under pressure. The properties claimed for ambroïne are:—(1) That it can be moulded into any form with but small loss of volume, leaving a surface smoother than ebonite under like conditions; this surface is said to be brilliant and polished; working parts of objects moulded in it are said to fit rigorously if the moulds are right. (2) It is claimed to be an excellent insulator; a sheet 0·34 mm. withstands 5000 volts; a rod 1 cm. diam. and 25 mm. long, after 24 hours immersion in water, has 290 megohms, or, after drying, 1000 megohms. (3) It is not affected by light, and is only slightly absorbent of moisture. (4) It resists acids and is not easily affected by heat or boiling water. (5) It is claimed to be about twice as strong mechanically as ebonite; it has also greater resistance to compression. It is made in five qualities for special purposes, *i. e.* one quality that resists the boiling water, a second that holds out against the 5000 volts, a third that withstands the acid, and so on. Particulars as to the quality of the various materials with which ambroïne was compared are omitted; so also are the methods of testing. R. A.

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143. *Frequency Meters.* **M. Aliamet.** (Électricien, 15. pp. 2–3, 1898.)—This is a brief description of two new frequency meters devised by G. Moler and F. Bedell, and exhibited by them at the Detroit meeting of the American Association for the Advancement of Science. The first type involves the use of a very small synchronous motor, and the second of a stretched pianoforte-wire conveying the current and placed between the poles of a powerful magnet, the length of the wire being varied by means of a movable bridge until it is thrown into vibration, and thus made to emit a note. A. H.

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144. *Measurements by Alternating Currents.* **H. A. Rowland.** (Amer. Journ. Sci. 4. pp. 429–448, 1897.)—The author describes a system of measuring capacities and inductions by an electrodynamometer in which the main current (being generally the larger) is led through the fixed coil, and the induced current, or the current through a condenser, is led through the moving coil. These currents then differ in phase, and the resistances in circuit are varied till the phase-difference is 90°, when the deflection is zero. On this principle the author gives six methods for comparing capacity and self-induction, and six for measurement with mutually inductive coils. He describes, further, ten methods of comparing inductions and capacities, using a dynamometer in the ordinary way and balancing to zero-current by varying the resistances. Two methods also are given of determining capacity or self-induction in terms of resistance and frequency, by comparison of the dynamometer deflections. The author has found from experiment that by some of these methods the self-inductions of two coils can

be compared to within 1 in 10,000, and, as capacities, mutual- and self-inductions can be compared one with another, he advocates standards of self-induction for the measurement of all these quantities. He discusses the construction of these and the errors to which they are subject. In measuring resistances by alternating currents, the author claims that accuracy is increased a thousandfold by passing a strong current through the fixed coil of the dynamometer and the testing current through the movable coil.

G. H. BA.

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145. *Induced Currents.* **L. Arons.** (Annal. Phys. Chem. 63. pp. 177–182, 1897.)—The author calculates the current, resistance, and E.M.F. for an interruption accomplished in 0·003 second of a circuit containing a coil with an iron core, the original E.M.F. of the steady current being 100 volts. Just before total interruption the voltage exceeds 1 millim. The general theory is given. E. E. F.

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146. *Counter-E.M.F. of Aluminium Arc.* **V. von Lang.** (Annal. Phys. Chem. 63. pp. 191–194, 1897.)—The fact that an electrolytic cell of aluminium and an indifferent electrode such as carbon or platinum allows a free passage to a current passing from the carbon to the aluminium, but opposes it in the opposite direction with a counter-E.M.F. of 22 volts, may have some connection with the counter-E.M.F. of an arc between aluminium electrodes. Experiments with such an arc gave a counter-E.M.F. of 18·8. With one carbon electrode the counter-E.M.F. was greater for a current C—Al than for a current Al—C. An arc can therefore also be used for converting an alternating into a continuous current; but the loss is great, only 6 per cent. being so converted.

E. E. F.

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147. *Electric Arc.* **G. Claude.** (Électricien, 14. pp. 257–260, 1897.)—This is merely a summary of investigations on the behaviour of the electric arc under varying pressures of the surrounding atmosphere, and a discussion of the observed phenomena. Starting with the assumption that the temperature of the arc corresponds with that of ebullition of carbon, the author argues that increase of pressure in the surrounding atmosphere should cause an increase in the temperature of the arc, and explains the observed diminution in the brilliancy observed by Wilson under a pressure of 20 atmospheres by supposing the atmosphere to become a mixture of air and vapour of carbon at the higher temperature. W. G. R.

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148. *Efficiency of Alternating Arc.* **W. B. Burnie.** (Electn. 39. pp. 849–855, 1897.)—It is known that a peaked E.M.F. wave is best for transformers, and a flat one for arcs. The reasons for the higher luminous efficiency of the arc with flat-topped as opposed to peaked waves have hitherto been imperfectly understood. The researches of Blondel, Görges, and Fleming have

shown that the light emitted by an arc follows the rapid fluctuations of the current supplying it. The object of the present research is to ascertain whether the heat-radiation undergoes the same variations as the light-radiation. The apparatus used consists of an arrangement of mirrors, by means of which the direction of the radiation coming from the arc can be varied; a synchronous motor, carrying a slotted disc whose position relatively to the shaft may, by an ingenious device, be varied whilst the motor is running; a fixed slotted disc through which the radiation is transmitted at the instant of coincidence of the two slots; and a Joubert contact-maker for ascertaining the P.D. and current-waves. A Bunsen photometer is used for ascertaining the luminous intensity, and a bolometer made of tinfoil for determining the thermal intensity. Preliminary experiments showed that the direction of greatest luminous intensity was sensibly the same as that of greatest thermal intensity. This direction of greatest intensity was chosen in determining the fluctuations occurring during a period. The results obtained show that, although the thermal intensity fluctuates, the fluctuations are not nearly so great as those of the luminous intensity. *From this it follows that the fluctuations which occur during a period are due to temperature changes in the bright surfaces of the carbons, and not to changes in their areas.* Now the efficiency of the arc will be greater, the greater the ratio of the luminous to the thermal radiation. And since this ratio increases with the temperature, it follows that the highest temperature will also give the highest efficiency. But there is an upper limit to this efficiency—that determined by the temperature of volatilisation of carbon. If a larger current than that required to maintain this temperature be passed through the arc, a large amount of carbon will be volatilised uselessly, and the efficiency will be reduced. The conditions for highest efficiency are stated thus: the arc has in one particular condition the highest possible efficiency, and so the current-value should rise rapidly to a maximum after its passage through zero in order to destroy the effect of the cooling during this time, and to heat up the positive carbon till the desired state is reached. The current should then fall to such a value as will maintain this state, and remain constant for the remainder of the half-period. The best form of current-curve would therefore be one of which each half-wave consists of two parts, each flat-topped, the earlier part having a greater value than the later one. This fully explains why flat-topped waves give better results than peaked ones. A. H.

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149. *Electrical Conductivity Test.* **E. G. Willyoung** and **H. P. Harth.** (Elect. World, 30. pp. 579–581, 1897.)—This is an adaptation of the "Carey-Foster" method to the measurement of the conductivity of short lengths of copper rods or tubes for commercial purposes. The conductor to be tested takes the place of the bridge-wire. The two "fixed" coils and the two "reversible"

coils have known values. By observing two scale-readings, corresponding to the two positions of the "reversible" coils, a certain length of the specimen is determined; the resistance of this length is equal to the difference of resistance of the two "reversible" coils. From the measured dimensions and weight of the specimen conductivity can then be calculated. In exchanging the "reversible" coils there is risk of introducing unequal contact-resistances. To avoid this the "reversible" coils are themselves permanently connected to the bridge; the required resistance-differences are obtained not by exchanging, but by shunting these coils. It is shown that errors introduced by the method of shunting are less than those of the exchanging method. Thermal currents are reduced by making all the bridge-bars of copper. The slide-bridge, together with the specimen rods, are enclosed in a box during testing. For commercial purposes it is important to check the conductivity of the various supplies of copper by a quick test. The author can check about twelve specimens in an hour. In stated examples he gives the conductivity to two decimal places. R. A.

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150. *Electric Conductivity of Pine-wood.* **D. Mazzotto.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 134–141, 1897.)—In air-dried pine the absolute specific conductivity along the fibres was found to be 280×10^{-19} C.G.S. units; and this fell steadily to $0{\cdot}5 \times 10^{-19}$ as the wood was dried in a stove at 100° C. Across the fibres the conductivity ranged, under the same conditions, from 112×10^{-19} down to $0{\cdot}0125 \times 10^{-19}$. It is, however, to be remarked that the values thus found for the conductivities are still a little too small, since the diminution of the index of refraction and of the dielectric constant, which take place on desiccation, and the smaller values which these present perpendicularly to the fibre, modify the apparent value of the conductivity. A. D.

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151. *Law of Electric and Thermal Conductivities.* **F. A. Schulze.** (Annal. Phys. Chem. 63. pp. 23–28, 1897.)—According to Wiedemann and Franz, the ratio between the thermal and electric conductivities is approximately the same for all metals, being about $1{\cdot}6 \times 10^{3}$ for Pb, Zn, Sn, and Cd according to Kirchhoff and Hansemann. The various specimens of iron and steel examined showed different values from these. The author determined the two conductivities for six specimens of iron and manganese steel. The ratio of the thermal to the electric conductivity was $1{\cdot}406 \times 10^{3}$ in the manganese steel specimen, while some of the iron rods go as high as 2·3 or even 7×10^{3}. The ratio does not increase with the coercive force. E. E. F.

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152. *Electrolytic Conductivity by Rapid Oscillations.* **J. A. Erskine.** (Annal. Phys. Chem. 62. pp. 454–459, 1897.)—The resistance of an electrolyte may be determined by observing

the thickness required to produce a given screening action upon electric oscillations. According to J. J. Thomson, the screening action is directly proportional to the conductivity. The author immersed an oscillator, consisting of a ring with two gaps, in an evaporating basin filled with petroleum, and placed another dish with a flat glass bottom on the top. This dish contained a similar receiver, immersed in the electrolyte to be studied. The smaller gap of the resonator contained a coil of wire surrounding a testing-needle acting upon a magnetometer. The observation of the sparks in the resonator was replaced by an observation of the magnetometer deflection as affected by the currents traversing the demagnetising coil. The demagnetising effect produced across any thickness of the electrolyte was compared, by interpolation if necessary, with the demagnetising effect produced across the same thickness of some standard solution, and the ratio thus obtained was the ratio of the resistance. In the following table the resistances thus obtained are compared with those obtained by Kohlrausch for continuous currents.

Substance.	Density of solution.	Resistance.	Resistance for continuous currents.
NaCl	1·035	2·50	2·44
"	1·109	1·0	1·0
"	1·19	0·77	0·77
H_2SO_4	1·104	0·30	0·30
HCl	1·049	0·25	0·26
HNO_3	1·035	0·52	0·53
KCl	1·10	0·79	0·81
NH_4Cl	1·042	0·62	0·64
NaOH	1·057	0·81	0·79
K_2CO_3	1·192	0·81	0·85
KNO_3	1·133	0·94	0·92
$NaC_2H_3O_2$	1·051	3·41	3·41

The waves used were 170 cm. long in petroleum. The standard solution in every case was a NaCl solution of density 1·109. The temperature was 18°. The author also tried whether a badly conducting liquid of high dielectric capacity produced any perceptible screening. A layer of water 1·2 cm. thick produced no perceptible screening. E. E. F.

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153. *Temperature Coefficients* (*Electrolytic*). **C. Cattaneo.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 89–94, 1897.)—The author found some years ago that the electrical conductivity of ethereal saline solutions diminished at higher temperatures, contrary to the general rule for liquids, but similarly to the rule for metallic conduction. By a series of experiments, which were somewhat complicated through loss of ether by evaporation or by the absorption of water-vapour, it was found that solutions could be made which offered great resistance and in which the conductivity did not vary with

the temperature to any material extent. Such a solution may be made by mixing, say, 75 of alcohol with 100 of ether, both as nearly as possible anhydrous, adding a small trace of ferric chloride; then tentatively vary the temperature and observe the conductivity, adding drops of alcohol or of ether as the case may be, until the conductivity remains the same under variations of temperature; then hermetically seal up this solution. The proportion of ether to alcohol depends on the concentration of the solution. Chlorides of gold, of platinum, of mercury also act in the same way; and with chloride of gold the proportion of alcohol present in the mixture of alcohol and ether is smaller than it must be in the case of ferric chloride. A. D.

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154. *Theory of Galvanic Polarisation.* **A. Oberbeck.** (Annal. Phys. Chem. 63. pp. 29–35, 1897.)—F. Streintz has maintained that the determination of the galvanic polarisation in the original circuit is impossible, even when alternating currents are employed. The author shows that this is not proved, and makes the following assumptions:—(1) In the case of feeble polarising forces the electrolytic cell behaves like a condenser, or, rather, like two condensers in series. (2) With stronger forces this assumption is only approximately true, but the capacity is a function of the polarisation, and increases with it. (3) The capacity becomes infinite when a superior limiting value of the polarising force is reached, which coincides with the maximum polarisation. From that point onwards the polarised cell acts like a constant cell in opposition to the primary current. There is another element, viz. the spontaneous depolarisation, or the loss of effectiveness of some of the polarising ions with time; but this process is not yet well understood. Neglecting this process, we have

$$\mathrm{R}i=\mathrm{E}-p$$

under all circumstances. The assumption (1) is complied with by

$$\mathrm{C}\frac{dp}{dt}=i,$$

where C is the constant capacity of the cell. Taking in assumption (2), the right-hand side of the last equation becomes eventually

$$\left(1-\frac{p}{\mathrm{P}}\right)i-kp,$$

where P is the limiting polarising force above mentioned. The polarisation may then be expressed in terms of the current-strength by the formula

$$p=\frac{\mathrm{P}i}{i+k}.$$

As the current increases the polarisation maximum is approached asymptotically. When the polarisation is very feeble, the depolarisation at break consists of a quick current-impulse followed by a prolonged constant residual current. Most of the phenomena can be described as producing an apparent increase of resistance, which is strongest for the feeble resistances and which vanishes at and above the maximum polarisation. The observations of polarisation hitherto made have not been fruitless. They have led to conceptions concerning its nature which are, on the whole, correct and only require filling out in detail. E. E. F.

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155. *Measurement of Self-Induction.* **M. A.** (Électricien, 14. pp. 299–300, 1897.)—This is a method due to Herr Thiermann, professor of physics at l'École polytechnique, Hanover. The method consists in measuring the steady current flowing round the coil whose self-induction is to be measured by means of an ammeter, and the induced transient current by means of a standardised ballistic galvanometer. The self-induction of the coil is then proportional to the ratio of the induced to the steady current passing through it. The chief feature of the method is the use of a particular type of key, by means of which the circuit remains a closed one when the battery-circuit is open. W. G. R.

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156. *Magnetic Testing Apparatus.* **R. B. Treat** and **J. W. Esterline.** (Elect. World, 30. pp. 696–697, 1897.)—The apparatus described resembles in some respects Ewing's Permeability Bridge, and in others the apparatus used by Ayrton. It consists of two massive yokes of wrought iron, provided with a clamping arrangement for holding two test-bars placed side by side as in Ewing's Bridge. Each bar is surrounded by a coil, and the number of effective turns in one of these coils may be varied by steps of one turn at a time, an equivalent resistance being thrown in as each turn is cut out. The yokes curve back over the test-bars, and are bored out to form two pole-pieces, between which is placed a small armature of the Pacinotti type. The length of test-bar between yokes is 4π cm. The area of air-gap at the joint with yokes is 32 times the area of test-bar; the length of air-gap between armature and pole-pieces is ·01″, and its area is 36 times that of test-bar. The armature is driven at 4000 revs. per min. The specimens, if solid, are in the shape of cylindrical rods 10 inches long and ·575″ dia. Sheet-iron specimens are built up into square rods, the side of the square being ·41″. There are three ways of using the instrument:—(1) One of the two bars is a standard bar, with which the other is compared, the revolving armature indicating any difference of magnetic potential which may exist between the yokes; (2) the hysteresis cycle of a specimen may be determined by removing the standard bar, and deducing **B** from the armature E.M.F.; (3) the **B**–**H** curve may be determined by this latter method if the specimen is demagnetised to start with. A. H.

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157. *Magnetic Properties of Iron and Steel.* **J. A. Fleming.** (Electn. 39. p. 860 &c., 1897.)—The paper commences with an

account of the fundamental facts of magnetic induction. Permeability, retentivity, coercivity, and hysteretic constant are considered in turn. The effects of temperature-changes on permeability are discussed, and the results obtained by Dr. Morris are exhibited in a series of curves. Generally speaking, for small magnetic forces the permeability is increased by a rise of temperature, while for large forces it is diminished. At a certain critical temperature (which lies between 700° C. and 900° C. for different specimens) the permeability drops very suddenly to a value not far from unity. Retentivity is not influenced by the presence of carbon in the iron, but coercivity depends very largely upon the chemical composition of the specimen. The hysteretic constant diminishes with increase of temperature and vanishes entirely at the critical temperature (if the iron is continuously heated up). Prolonged slow heating at 60° or 90° C. has, however, generally the effect of gradually increasing the hysteretic constant to two or three times its original value. By properly annealing the material, this effect may be to a large extent eliminated; steel may be produced with a non-ageing quality which is superior to that of iron.

The author next propounds a theory to account for the known ferro-magnetic properties of iron. There are many facts (such as the production of non-magnetic steel by the addition of manganese) which appear to point to the conclusion that it is the molecule, and not the atom, which is the magnetic unit. A brief outline of Ewing's molecular theory is given: this theory only accounts for observed facts by transferring the magnetic property of a mass of iron to one of its molecules; it does not attempt a solution of the ultimate cause of magnetic phenomena. The starting-point of the author's theory is that the atoms of all bodies carry on them electrical charges. The ferro-magnetic properties of iron may then be explained by assuming that its molecules consist of electrically-charged atoms arranged in a particular way and that they are in a state of rotation. A four-atom molecule is considered which consists of four electrons, two positive and two negative ones, grouped at the four corners of a square, the electrons at the extremities of a diagonal being of the same sign. If such a molecule be set rotating about a diagonal, the rotating electrons will be equivalent to an electric current: the molecule will, in other words, possess a certain magnetic moment. But an electron revolving in an orbit gives rise to radiation in the ether; and since the frequency of the waves emitted at ordinary temperatures is of the order 3×10^{13}, this may be assumed to represent the number of revolutions per sec. of the molecule. When the molecule is rotating steadily, the centrifugal action due to the masses of the revolving atoms is balanced by the electrostatic attraction. Using the results deduced by Lord Kelvin and others for the probable mass of a molecule of hydrogen, the author finds for the probable mass of an atom of iron $\frac{3}{10^{22}}$ of a gramme. Thus (making use of the known value of the electrochemical equivalent of iron) the probable charge carried by every atom of ferric or tetrad iron is $\frac{6}{10^9}$ of an *electrostatic* unit. From these data the radius of the orbit, and hence the magnetic moment of the molecule, may be determined. The greatest intensity of magnetisation will be obtained when all the molecules face one way. The intensity will then be equal to the magnetic moment of each molecule multiplied by the number of molecules in a cubic centimetre. This gives a maximum intensity of 1000 C.G.S. units. Since the actual limit is somewhere about 1700, it is seen that the hypothesis is capable of accounting for the limits of magnetisation actually observed. The effect of increasing the temperature is to break up some of the molecules into two-atom groups, which cannot have any magnetic moment. At the critical temperature this molecular decomposition proceeds rapidly: hence the sudden decrease of permeability. There is also other evidence to show that violent molecular disturbances take place at the critical temperature: the specific heat and temperature-coefficient of electrical resistance reach maxima values at this point.

In order to explain the various effects produced by temperature changes and the presence of carbon &c., the author supposes that every ferro-magnetic substance consists of a *matrix* of comparatively simple molecules (four-atom), throughout which ramifies a network or *web* of bonded molecules (consisting of a large number of atoms). The formation of the more complicated molecules constituting the *web* is facilitated by the presence of a polyvalent element, such as carbon, in small proportions. Heat breaks up the network, resolving it into simpler molecules, which will then possess greater freedom of movement. With low magnetising forces only the *matrix* will respond readily; but if heat be applied the *web* is to some extent broken up, and more molecules are free to respond to the magnetising force—*i. e.*, the permeability is increased. With high magnetising forces, on the other hand, even the molecules composing the *web* may be made to turn, so that a breaking-up of it by heat does not produce much effect. Heating to a high temperature breaks up the web, and if the cooling be slow, the web is not fully re-formed: hence the high permeability of annealed iron. The hysteretic *ageing* of iron is due to a gradual re-formation of the web. The presence of carbon, by facilitating the formation of a web, reduces the permeability. A. H.

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158. *Magnetic Properties of Tempered Steels.* (Électricien, 15. pp. 28–29, 1898.)—The article gives an account of some experiments by Mme. Sklodowska-Curie on the magnetic properties of steel from the point of view of their importance in the construction of permanent magnets. Rods and closed rings were studied. The rods were heated in an electric furnace by a spiral of platinum, then dipped in water. The heating current magnetised the rod, the magnetisation of which was followed by means of a deflection-

magnetometer. Mme. S.-C. finds that the rod only hardens if the temperature of the furnace is raised higher than that of recalescence ("température de la transformation magnétique"), that is to say, when the magnetisation is very small at the moment of hardening. The properties of importance are the residual magnetism and the coercive force. Steel (in the absence of other metals) containing 1·2 p. c. of carbon is best adapted for permanent magnets. Metals do not in general appreciably affect the residual magnetism, but many of them increase the coercive force. Nickel, chromium, and copper in small quantities appreciably improve the steel; but tungsten and molybdenum are the most remarkable in their action. The coercive force of ordinary steel may reach or pass 60; it attains values of 70 to 74 for tungsten- and of 80 to 85 for molybdenum-steel. The greater the coercive force the less the effect of shocks. A heating to 200° injures the steel; a heating to 100° is detrimental. It is best to heat the steel to 60°, taking care to partially demagnetise it immediately after having magnetised it to saturation. **A. Gs.**

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159. *Torsion and Magnetism.* **P. Drude.** (Annal. Phys. Chem. 63. pp. 9–15, 1897.)—The change in magnetic susceptibilities of a body in different directions due to mechanical deformations of an isotropic body depends upon two constants. If δ_1, δ_2, and δ_3 are the chief dilatations, and μ_1, μ_2, μ_3 the magnetic conductivities in the corresponding directions, then

$$\begin{cases} \mu_1=\mu-\mu'(\delta_1+\delta_2+\delta_3)-\mu''\delta_1. \\ \mu_2=\mu-\mu'(\delta_1+\delta_2+\delta_3)-\mu''\delta_2. \\ \mu_3=\mu-\mu'(\delta_1+\delta_2+\delta_3)-\mu''\delta_3. \end{cases}$$

When a wire suffers simple stretching, all three dilatations occur in each volume element, and $\delta_1+\delta_2+\delta_3$ is in general different from zero. But this sum is zero in the case of torsion. Hence the relations between torsion and magnetism cannot be explained by a simple stretching of the elements of the twisted wire. The simplest case, and the only one that can at present be dealt with by calculation, is that of a piece of iron freed from magnetism by incandescence, then deformed, and finally subjected to magnetisation. A reversal of the last two operations gives a different result, the currents in an induction-coil having the iron for a core being in the ratio 17·5 : 13·5. If the longitudinal magnetisation of such a twisted wire is supposed to be calculated solely on the basis of magnetic eolotropy, a very convenient and exact means is given for the calculation of μ''. The author obtains the formula

$$N=-\frac{\pi}{2}\mu''eiR^2,$$

where N is the number of lines of force traversing the section of the wire, R is its radius, i the current along the wire, and e the torsion per unit length. The value obtained for μ'' is −400,000, whereas the value found by Cantone was about double that. This may be due to a difference in the specimen. **E. E. F.**

160. *Magnetic After-Effect.* **I. Klemenčič.** (Annal. Phys. Chem. 63. pp. 61–65, 1897.)—Viscous magnetic hysteresis, or magnetic after-effect, is best observed in specimens of soft iron and in weak fields. In stronger fields the after-effect increases, but not in the same proportion to the temporary magnetisation; so that it soon vanishes in comparison with the latter. Experiments made with wires of various diameters show that the after-effect increases with the magnetisation and tends to a maximum, which is probably reached long before magnetic saturation. Thus, in varying the field from 0·16 to 1·63, the percentage after-effect decreases from 8·3 to 1·8 in a wire 0·6 cm. thick, and from 10·7 to 1·7 in a wire 0·4 cm. thick. The effect is the same whether the change of field is brought about by closing and opening the magnetising circuit or by reversing it. E. E. F.

161. *Atomic Magnetism.* **G. Jäger** and **S. Meyer.** (Annal. Phys. Chem. 63. pp. 83–90, 1897.)—The authors investigated the magnetic susceptibilities of water and of solutions of nickel, cobalt, iron, and manganese, by Quincke's manometer method. They found that the acid of the salt exerted no influence, and obtained the important result that the atomic magnetisms of Ni, Co, Fe, and Mn are exactly in the ratios of 2:4:5:6. It is highly probable that chromium fills up the gap between nickel and cobalt with the number 3. The absolute values for $\kappa \times 10^5$ for one gramme-atom are

Nickel	4·95	Iron	12·5
Cobalt	10·0	Manganese	15·0

The temperature-coefficient is about −0·0025. The value for water is −0·652 at 2°·4 C. E. E. F.

162. *Dielectrics in a Magnetic Field.* **K. R. Koch.** (Annal. Phys. Chem. 63. pp. 132–136, 1897.)—In view of the theoretical relations between the dielectric constant and the refractive index of a substance, it is interesting to enquire whether either of them is affected by a strong magnetic field. The author describes experiments on the refractive index of various liquids, both paramagnetic and diamagnetic, in various magnetic fields, homogeneous and otherwise, carried out by means of an interference refractometer. No change of refractivity due to magnetisation was observed. E. E. F.

163. *Magnetic Images.* **H. Jaeger.** (Annal. Phys. Chem. 63. pp. 137–141, 1897.)—The author investigated the field of a straight insulated wire lying on a broad thick plate of iron and traversed by a constant current, by means of an exploring coil and a galvanometer showing 10^{-9} amperes. The axis of the exploring coil was placed in the direction of the magnetic dip, thus eliminating the influence of the earth's magnetic field. It was found that the field

as modified by the iron plate was precisely that which would have been produced by the original wire *plus* another identical wire placed in the position of the reflected image of the former in the plate. The same was the case with a coil. This extends S. P. Thompson's conception of magnetic images to constant currents.

E. E. F.

164. *Demagnetising Factors.* **M. Ascoli.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 129–134, 1897.)—Experiments confirming previous results, that solid cylinders and bundles of wires have similar distributions of induced magnetism, the only difference being that the cylinders have slightly less permeability; and there is no difference between cylinders and bundles in respect of the demagnetising factors. A. D.

165. *Thermo-magnetic Properties of Bismuth.* **R. Defregger.** (Annal. Phys. Chem. 63. pp. 97–102, 1897.)—In repeating the experiments by Ettingshausen and Nernst on the thermo-magnetic transverse and longitudinal effect in bismuth, the author found that their contention as to the independence of the effect from the nature of the electrode wires does not apply to the longitudinal effect. They got rid of the thermo-electric currents altogether by using a peculiar shape for the plate of bismuth in which the warm and cold portions of the plate are brought into the circuit by pieces of the metal itself. The abolition of the thermo-currents annuls the longitudinal effect. It is seen, therefore, that a thermo-magnetic longitudinal effect, corresponding to the thermo-magnetic transverse effect, does not exist, but that the appearance is due simply to a change in the original thermo-electric current. This change is accounted for by the property of bismuth, discovered by Grimaldi, of changing its thermo-E.M.F. in a magnetic field with respect to other metals. The "galvano-magnetic temperature-difference" in a longitudinal direction observed by Nernst, must be interpreted as implying that the amount of Peltier heat at the ends of the bismuth rod changes in a magnetic field, thereby producing a slight change of temperature at these points. The change of resistance of bismuth in a magnetic field cannot be interpreted as a "longitudinal Hall effect." E. E. F.

166. *Carbon Coherer.* **F. J. Jervis-Smith.** (Electn. 40. p. 85, 1897.)—If the conditions are right, carbon coherers are extremely sensitive detectors for Hertz waves. To get the best results the carbon should be finely powdered, and the resistance should be such that, initially, a small current flows through the circuit. This last condition is obtained by providing pointed terminals that can be screwed to any required depth into the powdered carbon contained in a tube. Such a sensitive state is scarcely possible with metallic filings. The apparatus, set up in

this way, is a delicate indicator of approaching storms. The author tried to increase the sensitiveness still further by exhausting the containing tube; but a vacuum does not appear to improve matters. R. A.

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167. *Electroscopic Detection of Waves.* **A. Toepler.** (Annal. Phys. Chem. 63. pp. 183-190, 1897.)—Where a highly sensitive coherer cannot be employed, it is possible to demonstrate the existence of electric resonance-waves by a modified electroscopic arrangement. A fine aluminium wire is suspended between two upright cylindrical metallic rods, one of which is put to earth. To give the utmost freedom of suspension, the wire is attached to a steel needle, which in turn is held by a magnet. It oscillates about its point, and the magnet is only just powerful enough to keep it suspended. An image of the wire is thrown on a screen, and secondary sparks of a length of only 0·002 mm. length are indicated by the vibrations of the suspended wire. Resonance has thus been detected at a distance of 21 m. across intervening objects. E. E. F.

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168. *New Indicator of Electric Waves.* **A. Righi.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 245-246, 1897.)—In the course of experiments on the passage of electricity through rarefied gases, it was noticed that when a tube of rarefied air was connected up to a battery of electromotive force not quite sufficient to drive a current through it, very small disturbances, such as the approach of the hand to the tube, caused the current to flow and the tube to become luminous. The author finds that under certain conditions the electric waves generated by the discharge of an electrical machine produce the same result. The passage of the current may be aided or hindered, according to the pressure of air in the tube, the form of the tube, and the position and distance apart of its electrodes. Cessation of the waves causes cessation of the current in some cases, so that a galvanometer or a relay in the circuit of the battery and tube would receive signals transmitted by the electric waves. The instrument has about the same sensitiveness as the coherer, with the advantage that no shaking is necessary after the reception of each wave. As in the case of the coherer, the action of the wave seems to take place, not on the tube itself, but on the conductors connected with it.

The tubes with which the above results were obtained were constructed as follows:—They are very small, spherical or nearly so in shape, and carry two wire electrodes tipped with platinum, each of which is bent at a right angle at its end so as to form the adjacent sides of a rectangle. The point of one electrode is then turned at a right angle against the cylindrical part of the other one, and is separated from it by about a tenth of a millimetre. The pressure of the air in the tube is very nearly that for which the smallest number of cells is required to drive a current through it, and the number of cells used (copper—water—zinc) varied from 300 to 600. J. L. H.

169. *Period of Oscillation in Lecher Apparatus with Secondary Wire Appendices.* **D. Mazzotto.** (N. Cimento, 4. 6. pp. 172-185, 1897.)—The Lecher apparatus gives a fundamental electromagnetic wave and another, secondary, of much smaller wavelength. The present note is devoted to calculating the period of the fundamental wave.—In the apparatus, two condensers, equal to and parallel with one another, have their nearer plates connected by short wires with metallic balls between which there is a spark-gap. The further plates are connected with two long parallel "secondary" wires. According to Cohn and Heerwagen, the two condensers when the spark passes form a system of two condensers in cascade, equivalent to one of half the capacity of either; and we may assume the two proximal extremities of the secondary wires to be connected with the two plates of such a single condenser of half capacity. If from the end of one secondary wire to that of the other a wire is fixed to serve as a bridge, waves from the spark are reflected on reaching the bridge and form stationary waves along the secondary wires. In that case (Cohn and Heerwagen) the wave-length λ is, when there are no nodes between the condenser and the bridge—and when z is the length of either secondary wire up to the bridge, d the distance between the two parallel secondary wires, R the radius of either, and C the joint capacity of the condenser—

$$\lambda = 8\pi \mathrm{C} \log (d/\mathrm{R}) \,.\, \tan (2\pi z/\lambda).$$

In 1864 Kirchhoff had reached a similar result through considering the actions in the conducting wire. If we connect two equal wires with corresponding points of the secondary wires, these two wires being straight, fixed at right angles to the secondary wires, and having each one end free, the waves bifurcate at the junction, the part which runs along either appended wire being reflected at its extremity; and this applies both to the direct wave and to that reflected from the bridge. Without these additions the problem is comparatively simple: with them, we have to make equations for the current in the secondary wire up to the junction, in the same beyond the junction, and in the appended wire itself, and we then have to eliminate arbitrary constants with the aid of limiting cases. Working this out, we find

$$8\pi \mathrm{C} \log \frac{d}{\mathrm{R}} = \lambda \,.\, \frac{\cot (2\pi a/\lambda) - \tan (2\pi b/\lambda) - \tan (2\pi a/\lambda)}{\{ \left(\cot(2\pi a'/\lambda) - \tan (2\pi b/\lambda)\right) \tan (2\pi a/\lambda) \} + 1},$$

in which C is the electrostatic capacity of the condenser, d the distance between the two parallel secondary wires, R the radius of section of either, λ the wave-length, a the length from condenser to junction, a' the length from junction to bridge, and b the length of either appended wire. This equation contains no unknown terms except λ.—If the condenser be suppressed, we have the case of the junctions placed between two bridges, in which case

$C = \infty$, and

$$\cot(2\pi a/\lambda) + \cot(2\pi a'/\lambda) = \tan(2\pi b/\lambda).$$

If there be no appended wires we have $b=0$ and

$$8\pi C \log\frac{d}{R} = \frac{\lambda}{\tan\big(2\pi(a+a')/\lambda\big)},$$

which, making $a+a'=z$, coincides with the formula of Cohn and Heerwagen; and further,

$$\cot(2\pi a/\lambda) + \cot(2\pi a'/\lambda) = 0;$$

$$\therefore\quad \sin\big(2\pi(a+a')/\lambda\big) = 0;$$

or $(a+a')=z$, the length of the wire from condenser to bridge, is a whole number of half wave-lengths.—Tabulated experimental results, showing how the primary wave-length differs according to the length of the appended wires, amply confirm the formula given. The variations in this wave-length are small in comparison with the original wave-length. As the distance between the bridge and the condenser goes on increasing, a limit is reached at which the wave-length is the same as if there had been no condenser in the circuit; and then there are nodes at the condenser. On using the bridge as a source, experiments with appended wires and a bridge beyond the first bridge give results which confirm the formula for the case of the suppressed condenser. A. D.

170. *Coexistent Electrical Vibrations in the Blondlot Apparatus.* **D. Mazzotto.** (N. Cimento, 4. 6. pp. 186–191, 1897.)—In the Blondlot apparatus (C. R. 114. p. 283, 1892), as in the Lecher (see preceding Abstract), there are waves produced whose length differs with the position of the first bridge, and shorter secondary waves; but there are also still shorter or tertiary, and occasionally again still shorter or quaternary waves. These sets of waves are in general far from presenting harmonic ratios between their frequencies. The length of these waves varies continuously but according to different laws, as the first bridge is shifted along the secondary wires. There are positions of the bridge in which there appear to be incompatibility between the proper vibration in the primary circuit and the secondary vibration, so that the latter is produced not at all, or only very feebly. The period of the primary vibration, when the first bridge is near the exciter, agrees sensibly with the Thomson formula; and it increases equally, whether with increase of the capacity or with the self-induction of the exciting circuit. The period of the secondary vibration depends much less than the former upon the capacity of the exciting circuit, but it increases very rapidly with the self-induction of the exciter or of the secondary circuit. A. D.

171. *Secondary Waves from Dielectrics.* **A. Righi.** (Mem. R. Accad. della Sci. dell' Istit. di Bologna, 5. T. 6.)—If a non-conductor be placed in a dielectric traversed by electromagnetic waves, and if there be a difference between the dielectric constants of the substances, the body immersed—behaving like a resonator—acts as the source of secondary waves. The cases where the bodies are spheres or cylinders are worked out in some detail. A. Gs.

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172. *Kathode Rays.* **A. Battelli** and **A. Garbasso.** (N. Cimento, 4. 6. pp. 5–8, 1897.)—Kathode rays, when they traverse a material obstacle, traverse it with all their original properties; and if they are modified in their behaviour, this is due to the changed conditions of the surrounding medium. A. D.

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173. *Valve Action in Vacuum Tubes.* **E. Hagenbach.** (Annal. Phys. Chem. 63. pp. 1–8, 1897.)—Investigates the difference in the current-strength of vacuum discharges in different directions between a point and a disc. The discharge is a single spark from the secondary of an induction-coil, and is measured by a ballistic galvanometer inserted in the secondary circuit. Eighty different pressures are employed. When the disc is the anode, the current increases until the pressure is reduced to 10 mm. A minimum occurs at 0·08 mm., and after that the current increases slightly, probably owing to the generation of X-rays. When the point is the anode, the maximum occurs at 2·68 instead; and at that point the current is more than twice as strong as it is in the reverse direction. At very low pressures the case is reversed, and the current proceeds with greater ease from the disc to the point than in the reverse direction. E. E. F.

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174. *Stratified Discharge in Open Air.* **M. Toepler.** (Annal. Phys. Chem. 63. pp. 109–116, 1897.)—A well-defined stratification of the ordinary spark-discharge in air may be brought about by interposing a semi-conducting plate of dry slate, granite, syenite, or basalt in its path. The discharge is best obtained from an influence-machine through a circuit containing a large water-resistance, which prolongs the spark to a duration of about ¼ second. The author used a voltage of 80,000, obtained from one of his 60-plate machines. It is important to notice that the stratifications are seen next the kathode, and not in the positive light, as in vacuum discharges. Sometimes as many as 6 strata are seen, separated from the white surface on the kathode by a very narrow dark space, corresponding evidently to the dark space observed in vacuum tubes. The strata retain a fixed distance from the kathode, however the latter or the semi-conducting plate may be shifted. They correspond roughly to equipotential surfaces round the kathode. E. E. F.

175. *Screening Effect of Luminescent Gases.* **E. Wiedemann** and **G. C. Schmidt.** (Annal. Phys. Chem. 62. pp. 460–467, 1897.)—If rarefied gases are made to glow by oscillating currents in their vicinity, the greatest luminosity proceeds from the portions of the gas next the exciter, the rest being screened by the glowing gas. The authors placed a vacuum-tube with electrodes against the terminal condenser-plates of a Lecher wire system. This tube was exhausted until it exhibited a considerable dark space about the kathode. On placing a small electrode-less tube behind it, the latter responded to the glow when placed behind the dark space, but not behind the positive light column. When the pressure was reduced to the extent of filling the whole tube with kathode rays, it exerted no screening action on the waves proceeding from the Lecher system. On the other hand, no screening action could be produced by a fish-tail gas-burner, nor a Bunsen burner by itself, nor a Bunsen burner coloured by sodium or lithium salts. Vacuum-tubes traversed by high-voltage currents screen against electrostatic forces. This screening is probably due to electrostatic charges on the tube-walls due to transverse currents across the tube produced by the slight difference of potential due to the presence of the charged body. Similar transverse currents may also account for the electrostatic deflection of kathode rays observed by Jaumann. E. E. F.

176. *Canal Rays.* **E. Wiedemann** and **G. C. Schmidt.** (Annal. Phys. Chem. 62. pp. 468–473, 1897.)—The canal rays, discovered by Goldstein, form the first kathode layer, and may be studied by perforating the kathode. The authors describe a convenient set of tubes for obtaining them. A compound tube is separated into two compartments by a transverse partition of wire gauze or grating, which also forms the kathode. Anodes are inserted at both ends, and on connecting up one of them, canal rays are obtained in the opposite compartment. In another pattern, the tube contains two successive partitions, and the canal rays are obtained in the space between them. Both types of tubes should be narrow. The spaces containing canal rays exert a screening action upon electric waves, similar to that exerted by luminous gas discharges. They also reduce the discharge potential, as may be proved by a spark-gap mounted in parallel with the two partitions. It may be more strikingly proved by attaching a side tube with a perforated kathode to the main tube in such a manner that the canal rays from the side tube fall upon the main kathode. The discharge potential in the main tube is thereby considerably reduced. If electrodes of plain wire are introduced into the path of the canal rays, transverse currents are considerably facilitated by their influence, both in the case of discharges from an influence machine and from a battery. E. E. F.

177. *Discharge across Small Air-gaps.* **E. Salvioni.** (Atti dell' Accad. Medico-Chirurgica di Perugia, 9. 3. 1897.)—Two small spheres of amalgamated platinum (obtained by passing an electric arc from a platinum wire to the surface of mercury) are attached to platinum wires which are fixed by insulating material to a frame of copper made by bending a plate twice at right angles. The apparatus is placed in a brass box with double walls: by means of a water-jacket the temperature of the interior may be changed; and then, in consequence of the different rates of expansion of platinum and copper, the distance of the spherules may be altered. To determine the temperature of the copper frame a thermo-electric couple is used; and in the circuit is placed a battery of 300 Volta elements and a Nobili galvanometer. Starting with so high a temperature that no current passes, it is found that as the temperature sinks a moment comes when the circuit is *just* closed by 300 elements; then later on it is just closed by 200, and so on until finally two elements only suffice to close it. It is found that when the current from a certain number of elements has actually passed, that from a much smaller number will also pass: this state of extra conductivity is permanent, but may be removed by mechanically disturbing the apparatus. When the temperature is such that the circuit is not closed but the critical point is nearly reached, a very slight mechanical disturbance produces discharge and the passage of electricity continues. The apparatus is a sort of elementary "coherer." The author calculated the distances of the spherules for the different temperatures by the method of fringes, and found distances extraordinarily small as compared with the smallest found by Lord Kelvin (corresponding to the spark between two slightly curved planes). G. B. M.

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178. *Potential of Spark Discharges.* **R. Swyngedauw.** (Comptes Rendus, 125. pp. 863–865, 1897.)—In this note the author briefly defends his work (see Phys. Soc. Abstracts, No. 540, 1897) against an attack made on it by Jaumann, the more complete reply being reserved for another occasion. E. H. B.

ELECTRO-CHEMISTRY AND CHEMICAL PHYSICS.

179. *Molecular Volumes of Liquids.* **R. Nasini.** (Roma, R. Accad. Lincei, Atti. 6. 2. pp. 199–208, 1897.)—The papers contain a thorough examination and criticism of some laws which have from time to time been enunciated by Traube. A. Gs.

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180. *Atomic Weights of Argon and Helium.* **H. Wilde.** (Comptes Rendus, 125. pp. 649–651, 1897.)—The number for argon deduced from its specific heat is 40, which would bring it in the periodic system into the position already occupied by calcium, an element with which it has no more analogy than it has with the families on each side of it. On the other hand, its relationship to nitrogen being similar to that of ozone to oxygen, the author has attempted to effect the conversion of the one into the other. Dry atmospheric nitrogen at −76° C. and 1 mm. pressure was submitted to the silent discharge for 8 hours without any change in the spectrum. Strong induction-sparks between various metallic electrodes at 20 atmospheres pressure, and also under other conditions, had equally negative results, thus indirectly supporting the elementary character of argon. In M. Wilde's table of elements, founded on multiples of their atomic weights, nitrogen ranks as $2H \times 7$, and argon, if its atomic weight be 21, as $3H \times 7$, silicon being the next member with $4H \times 7$. Ramsay and others have placed helium between H and Li, although such a position would necessitate either another horizontal series of at least 7 members, or the displacement of the vertical series, introducing further confusion into the "pretended periodic system." M. Wilde classes helium as $H \times 2$, at the head of the second series in his table (Manchester Memoirs, 1878, 1886, 1895).

See also C. R. 120. p. 584, 1895; Phil. Mag. 40. p. 466, 1895; B. A. Report, 1897; Nature, Aug. 19, 1897, p. 380. S. G. R.

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181. *Vapour-Pressure of Efflorescent Hydrates.* **G. Tammann.** (Annal. Phys. Chem. 63. pp. 16–22, 1897.)—The investigation dealt with those solid hydrates which, like magnesium platinocyanide, remain transparent during efflorescence. The substances were suspended in glass pails inside bottles containing sulphuric acid of known strength, and were weighed at intervals until equilibrium was established. The curves obtained show that the behaviour of zeolites, like heulandite, chabasite, and desmine, differs from that of $MgPtCy_4 + 7H_2O$. The diminution of vapour-pressure with loss of water in the latter is slow at first, and afterwards very rapid, whereas the reverse holds for the zeolites. The author thinks that the zeolites are admirably adapted for

serving as semipermeable membranes in osmotic pressure measurements, since they will assume the vapour-pressures of any solutions with which they may be in contact. E. E. F.

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182. *Combination of Hydrogen with Oxygen.* **Berthelot.** (Comptes Rendus, 125. pp. 675–679, 1897.)—An account is given of the results of experiments made to find if compounds which readily absorb water exercise any influence on the combination of hydrogen with oxygen. It was found in each case that the presence of hydrochloric acid gas, fluoride of boron, dry sulphurous acid gas, and phosphoric anhydride did not exercise any marked influence on the combination. The action was *nil* at 100° and but slight at 280°. In the case of sulphuric acid which is reduced by hydrogen, all the hydrogen disappeared in 5 hours when the temperature was 280°. A small fraction of the oxygen also disappeared, but this may have been taken by the sulphurous acid. The presence of these substances must have made the combination more active, if this combination was regulated by an equilibrium limited by the presence of the vapour of water, whether the combination is susceptible of becoming total or not. The result observed is explained better if the combination is unlimited but excessively slow at 280°. J. J. S.

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183. *Artificial Diamond.* **Q. Majorana.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 141–147, 1897.)—In Moissan's method carbon is highly heated under great pressure and assumes the denser crystalline form whose sp. gr. is 3·5 as against, say, 2·5 for graphite and less than 2 for amorphous carbon. The carbon softens under the high temperature to which it is exposed, a fact known since Despretz's experiments: and it is easy to demonstrate this by passing a heavy current through an arc-lamp carbon, which becomes flexible. Moissan's method leaves it doubtful, however, whether the solubility of the carbon in the chilling metal may not have something to do with the result. The author applies a more direct method of heating and then applying pressure. The heating is effected by the electric arc: the pressure is applied by explosives. The apparatus, which is described, stands 5000 atmos. pressure. One blow raised the specific gravity from 1·52 (sugar carbon) to 2·28, and the appearance was that of laminated graphite. On powdering the mass and treating it with boiling hydrochloric acid in order to remove any iron, and then alternately with aqua regia, sulphuric acid, and hydrofluoric acid in order to remove any amorphous carbon; then with chlorate of potash and nitric acid to remove graphite; and finally washing with hydrofluoric acid and boiling sulphuric acid,—a residue was obtained, very small in quantity. On this being shaken with bromoform (sp. gr. 2·9) and iodide of methylene (sp. gr. 3·3), a still heavier residue was left, consisting mainly of broken black diamond crystals with some

clear ones: all hard, powerfully refractile, isotropic, with facets or sometimes a mammillary surface, and burning completely in air when raised to the required temperature, with the characteristic appearance of the combustion of diamond, namely, that the mass first grows smaller as if it were subliming, and then minute particles rise from it, tremble in the surrounding air, and then disappear. A. D.

184. *Chemical Composition and Physical Properties of Liquids.* **E. van Aubel.** (Journ. de Physique, 6. pp. 531–535, 1897.)—Discussing various series of physical constants, the author concludes: It is not the case that isomers possess nearly the same coefficient of thermal dilatation; the differences are sometimes very great. The substitution of chlorine for H or HO in a molecule diminishes the thermal conductivity, increases the density, and lowers the specific heat and the latent heat of vaporisation: with bromine the effect is greater, and with iodine the effect is still more marked. Passing from an alcohol to the corresponding fatty acid, the density and the thermal conductivity go up while the specific heat and the latent heat of vaporisation fall; but for the higher terms of the series the thermal conductivity undergoes no change. A. D.

185. *Osmotic Pressures of Sugar Solutions.* **A. Ponsot.** (Comptes Rendus, 125. pp. 867–869, 1897.)—The osmotic pressures of solutions of cane-sugar are measured directly by means of Pfeffer's method. The height is measured at which the liquid stands in a glass tube attached to the semipermeable cell when equilibrium is attained. In order to maintain a constant temperature the apparatus is set up in a well below the physical laboratory of the Sorbonne. A solution containing 1·235 grams of sugar per litre, at 11°·8 gave osmotic pressures varying from 867 to 873 mm., three different cells being used. At 0°·8, the same solution gave 846 mm. A solution containing 0·6175 gram per litre gave, at 11°·8, 433–444 mm. The pressure of a perfect gas of the same concentration and temperature as the stronger solution would be 870 mm. T. E.

186. *Energy of Bases of Mixed Function.* **G. Carrara** and **U. Rossi.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 152–158, 1897.)—The term "bases of mixed function" is intended to cover such bodies as contain in their formula an acid and basic term such as glycocoll. The authors give the chemical grounds for the formula usually assigned to glycocoll, betaine, and other bodies. They discuss the possibility of the internal saturation of the molecule, particularly with regard to the theory of electrolytic dissociation. They then consider the grounds for regarding the conductivity of solutions as a convenient method of investigating the properties of these weak bases. They discuss the general expressions for the amount of dissociated salt in terms of the constants of affinity. A. Gs.

187. *Electrolytic Conductivity of Bases of Mixed Function and of their Hydrochlorates.* **G. Carrara** and **U. Rossi.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 208–216, 1897.)—The authors give in this paper the numerical values of the conductivity of various solutions, with the physical deductions in tabular form. They discuss salts of betaine, and other bodies of that nature. A. Gs.

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188. *Electrolytic Conductivity of Liquid Ammonia Solutions.* **H. P. Cady.** (Journ. Phys. Chem. 1. pp. 707–713, 1897.)—The similarity existing between certain salts containing water of crystallisation and similar salts containing ammonia, has suggested the idea that water and ammonia might be analogous in some other properties, *i. e.* ionising power. The liquid anhydrous ammonia used in these experiments was the ordinary commercial ammonia used for the manufacture of ice, and was contained in a vacuum-jacketed test-tube, closed by a doubly-bored cork which supported two platinum plates as electrodes. A potential of 12 volts did not produce an appreciable current through the pure ammonia. 110 volts cause only a few hundredths of an ampere to flow, and the ammonia boiled vigorously. A small quantity of a soluble salt made a solution which conducted well, and in the case of sodium or potassium salts the solution becomes blue, but it becomes colourless when the current is stopped.—Metallic salts, *i. e.* Ag, Cu, Ba, give deposits of the metal on the kathode. Potassium iodide gives a dark grey deposit, probably KNH_2, on the kathode, and on the anode a bluish-black to olive-green explosive deposit, probably NH_3I. A solution of Na in ammonia conducts well, no deposit is formed on the electrodes and no gas is evolved. There is no polarisation current. The solution apparently conducts like a metal, and not as an electrolyte. A table is given of the values of conductivities at −34°. The author considers that ammonia possesses the same ionising power as water, and in many cases the ions travel faster in it than in water. S. S.

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189. *Chemical Action of Electrical Oscillations.* Part II. **A. de Hemptinne.** (Zschr. Phys. Chem. 23. pp. 483–492, 1897.)—The action of electrical oscillations on chemical compounds having been proved to be akin to that of sparking (Phys. Soc. Abstracts, No. 637, Oct. 1897), the influence of the wave-length is investigated by ascertaining the limiting pressure at which the tube remains luminous with waves of different periods. With methyl and ethyl alcohol the pressure increases with the wave-length, but with allyl alcohol and propionic aldehyde no alteration is observed, whilst with acetone it varies in an irregular manner. The slight variation in the spectra of the compounds as the wave-length is altered, is more probably due to the presence of varying amounts of decomposition products than to any direct action.

The author is investigating the effect of temperature on the limiting pressures, which appears to be considerable. A magnetic field is without action. J. W.

190. *Ozone.* (Elect. Rev. 41. pp. 601–603, 1897.)—The article gives a brief general description of the Yarnold apparatus for the production of ozone. The cost is stated to be less than 1*d.* per 2000 cubic feet of ozonised air (taking the cost of electrical energy at 4*d.* per unit). The principal practical applications of ozone are then explained. It has been successfully applied to the cleansing of brewers' foul casks; the drying and thickening of linseed and other oils; the seasoning of linoleum, and the manufacture of hydrogen peroxide. It may be used for the sterilisation of water, and is in general a powerful agent in sanitation. It has been found to alleviate the distressing symptoms in cancer and malignant growths by destroying the offensive smell. There are possible uses for it in metallurgical operations. A. H.

GENERAL ELECTRICAL ENGINEERING.

191. *Fuses and Circuit-Breakers.* **W. M. Stine.** (Amer. Electn. 9. pp. 350–351, 1897.)—From a series of experiments performed by the author, the blowing of a fuse depends upon (1) the length of the fuse; (2) the oxide film or coating which always forms, even when the fuse blows quickly, and to a very great extent when the fuse is heated up slowly, forming a tube which retains the molten metal and prevents the rupture of the circuit; (3) the condition and mass of the terminals; (4) contact with foreign substances; (5) whether the fuse is exposed or open freely to the air. The evidence of experimental tests shows that a fuse of a proper length, exposed to the air, properly placed in its receptacle, and mounted on copper terminals, is regular and reliable in its action, except where small time-constants may be of importance. The author considers that fuses should be excluded from switchboards, which should be protected by magnetic circuit-breakers; he also advocates the use of cut-outs in motor-circuits, and assures that they will open for currents not varying more than 3 or 5 per cent., being practically the same for creeping and impulsive currents, while their time-constant is a minute fraction of a second. W. G. R.

192. *Fuses and Circuit-Breakers.* **F. V. Henshaw.** (Amer. Electn. 9. p. 386, 1897.)—A protective device adapted to all cases of electric lighting and power-work should satisfy the following requirements:—

(1) The circuit should open when the current reaches a fixed maximum limit, whether the increase be gradual or sudden.

(2) The device should be capable of calibration, so that the limit-current is but little in excess of the maximum normal current.

(3) In case of short circuit the line should be opened without arc or flash.

(4) Under no conditions should any part of the device become hot enough to cause damage to itself or danger to surrounding combustible material.

(5) The device should admit of the instant closing of a circuit after it has come into action to open the circuit.

(6) The device should be unaffected by variation in local temperatures or exposure or position.

(7) The design should be such as to prevent tampering by irresponsible persons, tending to change the limit of current or render the device inoperative.

In a central station conditions 1, 2, 4, 5 are required, while the others are not essential; whereas all except 5 are important on customers' premises. The author therefore concludes that for station work cut-outs are preferable, while fuses are necessary for outside work. W. G. R.

193. *Fuses versus Cut-outs.* **H. H. Cutler.** (Amer. Electn. 9. pp. 305-306 & 385-386, 1897.)—These are two articles in which the advantages of fuses and the disadvantages of magnetic cut-outs are discussed. When magnetic cut-outs are placed on circuits in which an excessive current is only an occasional accident, they become clogged with dust and dirt, and when the accidental occasion does arrive they allow excessive currents to flow and perhaps refuse to act at all. Another strong objection urged against them is that, if they do act at the right moment, the interruption of the current is too sudden; and if they happen to be placed in, say, a shunt-motor circuit, in which there is a large self-induction, the sudden break gives rise to abnormal electromotive forces which are liable to damage the insulation or even break it down altogether.

In enumerating the requirements of a good circuit-breaker, the author states that (1) the initial movement should not open the circuit; (2) it should introduce sufficient resistance into the circuit to cut down the current to a safe amount, and then open the circuit; (3) it should introduce this resistance instantly only when the flow of current is extremely abnormal; (4) it should not act at all on a flow of an abnormal current lasting only for a short interval of time; (5) it should act when a slightly abnormal current continues for a long time; (6) the time which elapses before it starts to open should be governed by the temperature of the electrical devices which it protects; (7) whenever possible it should divert abnormal currents from going through the apparatus to be protected.

The function of the ideal circuit-breaker is to protect electrical apparatus from heating effects and from inductive effects or power to break down insulation. Both of these requirements bring in the element of time, upon which the ordinary magnetic cut-out does not depend at all. W. G. R.

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194. *An Accurate and Reliable Fuse.* **L. W. Downes.** (Amer. Electn. 9. pp. 386-389, 1897.)—This is a description of a fuse which the author has found to be a reliable one. It consists of an ordinary fuse-wire soldered to copper terminals, and at the middle of its length is placed an air-drum, the wire being threaded through it. The whole is placed in an enclosure and packed with some kind of filling the composition of which is not stated. Sand was tried and found unsatisfactory. W. G. R.

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195. *Insulators for High Tension.* **J. R. Haskin.** (Elect. World, 31. pp. 122-123, 1898.)—This article gives an account of the method employed for testing the porcelain insulators on the Niagara-Buffalo long-distance high-tension system of electrical transmission. It resembles the ordinary test used for telegraph insulators, but is much more severe. The insulators are placed in an inverted position in a square iron pan, the bolt-holes and the spaces between the cups are filled with salt water, and the current from a transformer is applied at from 20,000 to 40,000 volts. If

there is a flaw in the insulator, it is at once manifested by a yellowish spark. Experiment shows that when fresh water is used instead of brine, a much larger proportion of the insulators pass the test, but of these a great many develop subsequent faults. Of those that withstood the brine-test not more than 3 in 12,000 have failed on the Buffalo line. The author is therefore strongly in favour of brine. A rough estimate of the quality of a given sample of porcelain can be made by observing the effect of red-ink upon it: any porosity is at once revealed. In some parts of Western America power is transmitted at 50,000 and 60,000 volts on wires insulated only by the ordinary telegraph insulator of *glass*. In such districts the air is of course exceptionally pure and dry.

R. A.

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196. *Automatic Transformer-Switch.* **G. G.** (Écl. Élect. 14. pp. 164–165, 1898.)—The most effective method of reducing the light-load losses of transformers consists in switching them out as the load diminishes, so that all the transformers which remain in circuit are kept working at full load and high efficiency. Mr. Schlatter, of Budapest, has for this purpose during the last two years used a type of automatic switch which has given satisfaction. The method involves the use of a small auxiliary transformer whose primary and secondary are respectively joined in series with those of the main transformer. Included in the secondary circuit of the transformers is an electromagnet which acts on a mercury switch. The latter is closed as soon as the smallest current appears in the secondary, and short-circuits both windings of the auxiliary transformer. The primary of the main transformer is *always* across the mains, but since it is in series with the primary of the auxiliary transformer, and since the latter is designed so as to absorb the greater portion of the no-load power, the latter is reduced by about 95 %. The switch may be designed either for operating a single transformer or a group *en bloc*, or for throwing a bank of transformers into circuit one after another as the load increases.

[A detailed description, with illustrations, of the Schlatter switch is given in 'The Electrician' for January 14th, 1891.—*Abstractor*.]

A. H

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197. *Electromagnetic Speed-indicator.* **G. Claude.** (Ind. Élect. 7. pp. 8–9, 1898.)—This speed-indicator (L'entraineur Volta), which is primarily intended for use on cycles, comprises a metallic disc mounted on an arbor turning on jewels, etc. This arbor is provided with a pointer moving over a graduated scale, and its motion is controlled by a hair-spring. On opposite sides of this disc are arranged magnets mounted on a frame adapted to be rotated by the object whose speed is to be measured. These magnets cause Foucault currents to be generated in the disc, and so produce a torque on its arbor, this torque being proportional to the angular velocity of the magnets and being balanced by the

hair-spring. If desired, the instrument can be combined with a counter for registering the total number of revolutions of the magnets or a number proportional thereto. C. K. F.

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198. *Electric Lift.* **F. Hérard.** (Électricien, 15. pp. 65–69, 1898.)—This lift consists of a cabin supported by a cable which is provided with a counter-weight, and is passed over the drum of an electrically-operated winch used solely for raising the cabin. In order to render the lift as safe as possible, the cabin is provided at its underside with a tubular steel piston passing down into a cylinder containing water and in communication, through a controlling-valve, with a storage tank. This water serves to fill the space left as the piston rises, so that, when the winch stops, the cabin, through the medium of its piston, can be allowed to rest on the column of water in a perfectly stable manner. The descent is effected automatically under the combined action of the weight and of the hydraulic brake formed by the piston and cylinder. The valve controlling the inlet and outlet of the water to the hydraulic cylinder and the resistance-switch for the electric motor of the winch are coupled together by linkwork, and actuated simultaneously by means of a lever operated either by a cord passing through the cabin or by a rod at the landing-stages. This interconnected system is actuated partly by hand and partly by the action of a rolling-weight, so as to ensure that the motor shall always be started uniformly, an oil-cataract being provided for preventing violent motions of the valve-lever. The authors give figures showing that with a useful load of 210 kilos and lift of 16 metres, a single complete operation costs 0·021 franc. This system is due to Guyenét and De Mocomble. C. K. F.

DYNAMOS, MOTORS, AND TRANSFORMERS.

199. *Dynamo Efficiency.* **G. Claude.** (Électricien, 15. pp. 42–44, 1898.)—The methods based on Hopkinson's original plan of circulating power between two machines suffer from the disadvantage of being applicable only in cases where two machines identical in every respect are available. The following method, recently devised by M. Routin, gets over this difficulty, and enables the losses occurring in the machine to be completely analysed. These losses are :—(1) the ri^2 losses in the armature; (2) do. in the field; (3) hysteresis and eddy-currents; (4) mechanical losses (bearing friction and windage). The first two are easily calculated. The last two are obtained as follows :—Using the machine as a motor, run it up to a speed considerably above the normal; switch off both armature and field-currents, and by means of a tachometer attached to the machine determine the law connecting angular velocity with time. Repeat the experiment, but using a brake with a known load on the dynamo-pulley. Plot two curves from the two sets of readings, and find the tangents of their angles of inclination α and α' to the axis of time at the normal speed. If q stand for the (known) power absorbed by the brake at this speed, then we have for the mechanical losses the value $q \tan\alpha/(\tan\alpha' - \tan\alpha)$. A third experiment is next performed, no brake being used, but the field-current, which must have its normal value, being left on. Let α'' be the new value of the angle of inclination at the normal speed. Then we get for the losses (3) and (4) the value $q\,(\tan\alpha'' - \tan\alpha)/(\tan\alpha' - \tan\alpha)$. It is to be noted that the loss (3) so obtained is somewhat less than that which occurs when the machine is loaded, the latter loss being somewhat greater on account of the field-distortion; but in the majority of cases the error due to this cause is negligible. The brake should be arranged to absorb about 5 $^0/_0$ of the normal output of the machine. A. H.

[See also Mr. I. R. Ashworth in a letter to 'The Electrician' of Feb. 17th, 1893.—*Abstractor.*]

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200. *Efficiency and Speed of a Dynamo.* **A. G. Hansard.** (Electn. 38. pp. 401–402, 1897.)—In determining the relation between the efficiency and speed of a dynamo it is here assumed (1) that the output is proportional to the speed; (2) that the copper losses at full load are independent of the speed; (3) that hysteresis and friction losses are proportional to the speed; and (4) that the eddy-current losses vary as the square of the speed.

Let n = speed of dynamo,
Wn = output,
an^2 = eddy-current losses,
bn = hysteresis and friction losses,
c = copper losses (constant).

Then the efficiency η is given by

$$\eta = \frac{Wn}{Wn + an^2 + bn + c}.$$

Differentiating this with respect to n and equating to zero, it is found that η is a maximum when $an^2 = c$; that is, when the copper losses are equal to the eddy-current losses.

A graphic solution is also given. W. G. R.

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201. *Armature Inductance* (Discussion). **Goldsborough.** (Amer. Instit. Elect. Engin. 14. pp. 439–442, 1897.)—The main points considered in the discussion on the above paper are the variation of the inductance of an armature-coil with its position relatively to the pole-pieces, the effect of the mutual inductance of neighbouring coils, and the actual value of the self-inductance of a coil for the particular frequency at which commutation takes place. In an ordinary continuous-current armature with toothed core, the inductance of a coil is practically constant for any position under the pole-faces, and diminishes considerably for positions in the interpolar space. C. P. Steinmetz states that the mutual inductance of neighbouring coils produces no appreciable effect—unless two coils happen to lie in the same slot. He further points out that if the inductance of an armature-coil be measured by the method of reversals or by alternating currents of ordinary frequencies, the value so obtained is very much higher than that corresponding to frequencies from 500 to 1000 cycles per second. It is this latter value which has to be considered in dealing with commutation, as the frequency in such cases usually amounts to between 400 and 800. The smaller value for the higher frequency is due to the fact that for high frequencies the field-structure which is in the magnetic circuit of the coil under commutation is, on account of its solidity, incapable of responding to a rapidly varying magnetic force, the varying magnetic flux being constrained to pass through the air-gap across the top of the slot. A. H.

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202. *Single-Phase Motors.* **E. I. Berg.** (Amer. Electn. 9. pp. 204–205, 1897.)—The author briefly discusses the relative merits of different forms of single-phase motors, and gives data and curves relating to the performance of a 100-HP. single-phase induction-motor recently constructed by the General Electric Company. The motor has 12 poles, runs at 600 revs., and is wound for 2000 volts. The speed remains remarkably constant, the drop at full load being only 1·5 %. The following table shows the variation of the efficiency and power-factor with the load :—

Percentage of normal load......	25	50	75	100	125
Efficiency	68	81	84·5	82	82
Power-factor, per cent.........	43	62	72	76	78

The maximum output is 50 % in excess of the normal load. The starting device consists of a reactance coil connected in series with a non-inductive resistance, the two being joined across the mains. The mains and the junction of the two coils mentioned are connected respectively to three points in the winding of the motor. The latter is thus started as a multiphase motor, and the starting device is cut out when the motor has run up to its normal speed. No constructional details are given. A. H.

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203. *Rotary Converters.* **R. B. Owens ; D. W. Hawksworth** and **H. W. Doubrava.** (Amer. Instit. Elect. Engin. 14. pp. 385–396, 1897.)—This is an endeavour to investigate the effect of armature reactions in a rotary converter by obtaining curves showing the instantaneous distribution of induction over the pole-faces for different armature positions and conditions of loading. The method employed consists in measuring the instantaneous electromotive forces under different conditions generated in a series of equal evenly spaced coils of fine wire wound over the armature surface. The machine experimented upon is of the consequent pole type, having an output of 3·5 kilowatts at 110 volts and at a speed of 2400 revolutions per minute per minute. The machine was originally a continuous-current generator with a 54-part commutator, and was changed into a three-phase converter by placing slip-rings on the armature-shaft and connecting segments 1, 19, and 37 of the commutator respectively to rings 1, 2, and 3. No suitable tri-phase generator being available, it was used only to convert continuous into three-phase currents.

The machine was first run light as a motor, and a curve was obtained showing the induction distribution to be quite uniform over the polar surface, but slightly shifted in the direction opposite to rotation. When run as a motor on full load with an armature current of 32·6 amperes, the curve obtained shows a decided distortion of the field. When run as a rotary converter with the three limbs equally loaded with incandescent lamps, the armature current being 39·45 amperes, no shifting of the brushes was necessary to avoid sparking showing the small reactions in a rotary converter, and the curve shows uniformity of distribution of induction over the polar face. When run as a rotary converter with inductive load, very slight alteration of the curve is noticed.

Curves showing the E.M.F.'s between the legs of the rotary for different loads are given, as also are efficiency curves for the machine run as a motor and a converter.

In the discussion on the paper Mr. Dunn draws attention to the high resistivity of cast-iron as being four or five times that of steel.

Mr. C. P. Steinmetz remarks that in a polyphase rotary converter the resultant armature reaction of the machine as direct-current machine and as alternating-current machine are equal but opposite, thus neutralising each other, and all that remains of armature reaction are effects of higher harmonics which may be called higher harmonics of armature reaction. When the converter is used to change from alternating to direct current, further higher harmonics exist due to the difference in the wave-shape between the applied potential difference and the induced alternating counter E.M.F., which difference causes a current component consisting essentially of waves of higher frequency. W. G. R.

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204. *Rotary Transformers.* **J. E. Woodbridge** and **C. T. Child.** (Elect. World, 31. pp. 12–14, 1898.)—The object of this paper is to calculate the copper losses in a rotary converter. To simplify the mathematics it is assumed that the converter is working in such a condition that its power-factor is unity, and losses due to hysteresis, eddy-currents, and friction are neglected, so that the input may be taken to be numerically equal to the output.

Let V be the direct-current voltage and C the direct current in one path through the armature, so that the total external direct current is 2 C. The maximum instantaneous alternating voltage is then V, and the maximum alternating current is 2 C. If the converter is a single-phase one and if a is the angular distance of an armature-conductor from the point midway between the alternating current tappings, it is shown that the rate of heating of this conductor whose resistance is r is $C^2r\left(3-\frac{8}{\pi}\cos a\right)$, and the average heating effect is

$$\frac{C^2r}{\pi}\int_{\frac{-\pi}{2}}^{\frac{\pi}{2}}\left(3-\frac{8}{\pi}\cos a\right)da=C^2r\left(3-\frac{16}{\pi^2}\right)$$

$$=1{\cdot}38C^2r.$$

Thus it is seen that, under the conditions assumed, any direct-current machine used as a single-phase rotary will dissipate in copper losses 38 per cent. more energy than when working simply as a direct-current machine at the same output. To determine, therefore, the safe load of a machine with known generating capacity when worked as a single-phase rotary, let K be this safe transforming current-capacity; then

$$1{\cdot}38\ K^2r=C^2r;$$

that is $K=0{\cdot}85\ C.$

Hence, with unity power-factor, the rating of a single-phase rotary transformer should be 85 per cent. of that of a direct-current generator or motor of the same dimensions.

If the power-factor of the rotary is taken to be 0·8, the value of K is calculated to be 0·63 C. W. G. R.

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205. *Hysteresis Losses.* **F. Drouin.** (Électricien, 14. pp. 300–301, 1897.)—M. Lional Fleischmann showed some time ago how to

determine the R.M.S. value of an E.M.F. by a method depending on the properties of the centre of gravity of an area. Thus if e_1 is ordinate of the C.G. of an E.M.F. curve, and e its instantaneous value,

$$e_1 \int e\,dt = \tfrac{1}{2} \int e^2\,dt,$$

whence

$$\sqrt{\frac{1}{T}\int_0^T e^2\,dt} = \sqrt{\frac{1}{T} \cdot 2e_1 \int_0^T e\,dt},$$

where T is half the periodic time of the E.M.F.

Now if N is the maximum value of the total flux through an iron core due to a current flowing through n turns of wire wound round it, we have

$$\int_0^T e\,dt = Nn.$$

Thus

$$\sqrt{\frac{1}{T}\int_0^T e^2\,dt} = \sqrt{\frac{2}{T} \cdot e_1 nN}.$$

The hysteresis loss depends only on N. If, then, there are two differently shaped E.M.F. curves having the same R.M.S. value, we have

$$e_1 N = e'_1 N',$$

where e_1 and e'_1 are the ordinates of the centres of gravity of their areas, and N, N′ the corresponding values of the total flux; whence

$$\frac{N}{N'} = \frac{e'_1}{e_1}.$$

Assuming now the empirical law of Steinmetz, we see that hysteresis losses should vary inversely as the 1·6th power of the distances of the centres of gravity of the area of the E.M.F. curve from the axis of time.

Applying this to the case in which the E.M.F. curve is triangular or rectangular, the author finds that a rectangular E.M.F. curve causes hysteresis losses 1·182 times, and a triangular curve 0·937 times that due to a simple sine curve. W. G. R.

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206. *Converting Tri-phase into Mono-phase Currents.* **J. Lefèvre.** (Ind. Elect. 7. pp. 9–10, 1898.)—In this apparatus, due to Grassi and Civita, the three primary currents act on three separate coils of which the windings are united into a single circuit. The apparatus comprises three straight parallel cores, A, B, C, connected by two yokes. Each core carries two coils, one primary, the other secondary. The three secondary wires are connected in series, but the winding of C should be in the opposite direction to that of A; as regards B, the direction is immaterial. If the three primary

coils are wound in the same direction, it will be found, on closing the secondary, that the three primary currents are always of different amounts, it being the same with the amounts of energy absorbed. In a modified form, say 310 turns of wire are wound on each of the cores A and C, and for the central core B the diameter is doubled and the direction of the current is changed. Under these conditions, the quantity of energy absorbed with the secondary circuit open is very small. By uniting the three secondary wires, as above mentioned, the maximum useful effect is obtained; the efficiency is high and comparable with that of ordinary transformers; the distribution of the energy in the three primary circuits is very little different. Finally, if the secondary circuit be loaded, the difference of potential in the three-line circuits will not suffer the slightest variation. Moreover, various changes can be made in these arrangements: thus two primary coils can be wound on B, arranged in series with each other and with the coils A and C; the line-wires are connected to the free ends of A and C and to the point where the two coils of B are connected together. C. K. F.

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207. *Electrochemical Rectifier.* **Graetz** and **C. Pollak.** (Elektrotechnische Zschr. 25. p. 359, & 29. pp. 423–424, 1897.)—This process is based on the fact that, when an anode of aluminium is employed in an electrolytic cell and the electrolyte is such that oxygen will be generated at this anode, the current passing will be reduced to an extraordinarily high degree. This is probably due to the formation of a very badly-conducting film of oxide on the anode, which increases the resistance of the circuit, and also to a kind of condenser action between the electrode and the liquid, or dielectric polarisation, as opposed to the ordinary electrolytic polarisation. This latter view is based on the fact that each cell of this kind has a quite definite back-E.M.F. of 22 V., so that currents of lower potential generally do not pass through the cell. On reversing the current, however, the back-E.M.F. is less than 1 V. The kathode may be of carbon, platinum, or any other usable metal except aluminium, and the electrolyte alum solutions (sodium- and potassium-alum solutions) or dilute acids which generate oxygen on electrolysis.

If an alternate current be sent through a number of these cells arranged in series, the number being such that the polarisation at the anode is greater than, or at least equal to, the potential of the alternate current, it follows that the positive part of the current, in which the aluminium is the anode, is not allowed to pass through, whilst the negative part of the current does pass through. In this manner an interrupted direct current is obtained of half the strength of the original alternate current; loss of half the energy is, however, not involved in this. By arranging another battery, having a similar number of cells but with its poles reversed, in parallel with the battery above mentioned, across the alternator terminals, the other half of the alternate current may be obtained, a pulsating direct current then flowing *around the two branched circuits, i. e.* the positive current in one and the negative current in the other.

In a modified arrangement, a pair of oppositely-connected batteries are arranged at each terminal of the alternating P.D., and the other or opposite terminals of like batteries are connected together by conductors from which a direct current can be taken. By using sufficiently large cells, so as to bring down the resistance as much as possible, a maximum efficiency of 95 per cent. (energy) can be obtained (See also Phys. Soc. Abstracts, No. 673, Nov. 1897.)

A similar process was independently discovered and patented by Herr C. Pollak (Germ. Pat. No. 92564). C. K. F.

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208. *Converting Direct into Alternating Currents.* **H. S. Carhart.** (Amer. Electn. 9. pp. 121–123, 1897.)—This apparatus for converting direct into alternating currents comprises a square vessel containing a solution of $ZnSO_4$ (7–10 oz. to the quart). On two opposite sides of this vessel are arranged parallel Zn electrodes for conveying a direct current from, say, an accumulator, through the electrolyte. Into the electrolyte dip, for a simple alternating current, two zinc rods mounted diametrically opposite each other on an insulating disc at equal distances from the centre. This disc is mounted on a shaft whereby it can be rotated, and contact-rings, each connected to one of the zinc rods, are arranged on the shaft so as to engage with fixed brushes from which an alternating current can be taken. The zinc rods are arranged so as to move parallel to the zinc plates, so that, when a line joining the rods is perpendicular to the plates, the P.D. between the rods will be a maximum in one direction; when the said line is parallel to the plates, the P.D. between the rods will be zero; and when, in the continued rotation of the disc, the line is again perpendicular to the plates, the P.D. between the rods will be a maximum in the other direction; the variation of the P.D. in the intermediate positions following closely the law of sines. If four rods, arranged at angular distances of 90° from each other and connected to four contact-rings, are employed, a two-phase alternating current can be obtained; with three rods at 120° apart, and three contact-rings, a three-phase alternating current: and so on. The apparatus is chiefly designed for experimental or educational purposes; for example, in plotting P.D. curves, obtaining ratio between virtual and maximum E.M.F.'s, etc.; for which purpose the rotary shaft is provided with a pointer moving over a fixed graduated scale for indicating the angular positions of the disc and the zinc rods. C. K. F.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

209. *Power Transmission on the Continuous Current Series System.* **J. S. Hecht.** (Electn. 38. pp. 683–687, 1897.)—The author here discusses the advantages of a continuous current series system of distributing power electrically over alternating-current systems. The chief argument in favour of the former is that the switching in or out of a motor does not affect lights or other motors on the same circuit, whereas in the latter system the large starting currents and low power factors of induction motors, when running light, cause serious disturbance when switched in or out of the circuit. In the continuous current system regulation is so much easier than when working with alternating currents, that much less attention and fewer skilled attendants are required. Also the voltage difficulty is now overcome, since direct-current dynamos can now be built to give a safe working pressure of 3500 volts direct. The full main voltage is only used when required for full load, generators being switched in the circuit as the load increases. The switchboard is simple, including only ammeter, voltmeter, short-circuiting switch, and an automatic switch for cutting out the dynamo in case the pressure should rise above a certain value. No regulating rheostats are required at the generating station. Each motor on the circuit is provided with a speed regulator, two types of which are described. An account is given of the direct-current plant at Chaux-de-Fonds, which supplies power over a line of about 30 miles in length, the current having a constant value of 150 amperes at 1800 volts per generator, the total pressure being 14,400 volts. W. G. R.

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210. *Electric Power Distribution.* **M. Hoopes.** (Elect. World, 30. pp. 479–483, 1897.)—The author considers the relative advantages of systems when dealing with a section of line in which the drop is excessive and the amount of copper necessary is prohibitive. These are (1) the use of a special generator for the section; (2) the use of a booster; (3) the application of the three-wire system; (4) the use of multiphase currents and sub-stations. The value of the three-wire system for traction purposes has been much over-rated. It may often be more economical to raise the voltage on the section deficient in copper rather than introduce a three-phase network. W. R. C.

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211. *Power Transmission by Three-Phase and Continuous Currents.* **G. L. Addenbrooke.** (Elect. Rev. 40. pp. 587–588, 1897.)—The author gives a summary of the advantages and disadvantages

attending the use of three-phase as against continuous currents for the transmission of power. The cost of continuous and three-phase plant, both motors and generators, is very appreciably the same; and so also is the cost of starting resistances. With regard to the line, there seems to be a good deal of uncertainty; it would probably be impossible to estimate the exact difference in the cost of insulation of two cables, one intended for 3000 alternating, the other for 3000 continuous volts. Comparing a continuous three-wire system, with middle wire earthed, with a three-phase system (star grouping with centre earthed), and assuming the same P.D. between earth and any conductor in the two cases, it appears that the copper for the three-phase circuit is only about 78 % of that for the continuous-current one—if a power factor of 1 be assumed. On account of the power-factor in three-phase system being only about ·8, extra copper must be provided. There is thus little to choose between the two systems so far as the line is concerned. The main point of difference lies in the fact that three-phase motors can be run direct, without the use of transformers; whereas it is at present impossible to obtain continuous current motors of outputs below, say, 8 kilowatts which can be relied on to work satisfactorily at 3000 volts. For this reason three-phase currents are now available for power transmission in cases where continuous currents could not be recommended. A. H.

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212. *Three-Phase Plant of the Tide-Water Oil Company.* (El. World, 31. pp. 119-120, 1898.)—This plant has been specially designed on account of the dangers existing in using electrical devices in an oil factory. The generating consists of a 75-kilowatt 8-pole 60-cycle three-phase alternator, driven by an upright American engine with cylinder dimensions 15 × 15 inches, generating 150 horse-power at 180 revolutions per minute. Six circuits run from the power-house to different parts of the yard, three of which are two-wire for lighting purposes only, and three are three-wire for both lighting and power. The main and line voltage is 550 volts between any pair of the three wires. Fifteen motors are in use, and all are of the induction type. These are used to drive hoists, pumps, boiler-shop, tramway, and other work. In positions where an inflammable mixture of oil-vapours and air is not likely to exist, the rotors are fitted with an internal starting resistance which may be short-circuited by a hand-lever acting through a collar on the motor-shaft. For more dangerous positions the short-circuited secondary winding, pure and simple, is used; such motors being fitted with clutches or tight and loose pulleys, so that they may be started without load. The motors start with about 10 per cent. of their full rated running torque. All the motors are equipped with switches operating under oil, and the fuses are placed in boxes under the building.

The method of lighting the can-filling and freezing rooms is interesting. These rooms, while being the most dangerous, require to be well lighted. Ninety-seven lights are used in this room, each mounted in an air-tight inclosing globe on the extremities of the heavy gas-pipe conduits. Just above each lamp there is inserted in the pipe a cast-iron box with a bolted cover, in which is placed a bug cut-out. Rubber-covered wire is used, each wire of the circuit being also further enclosed by an insulating tube within the gas-pipe protection. In this way all possible danger of a spark occurring in the open air is avoided. W. G. R.

213. *Economics of Power Transmission.* **L. Bell.** (Amer. Electn. 9. pp. 205–207, 1897.)—This paper contains a discussion of the various factors which determine the success or otherwise of power-transmission schemes. The author works out at length a numerical example in which about 1000 H.P. is to be transmitted from a waterfall 15 miles distant. He considers the various items of cost of erection and working, and, on the basis of certain assumptions regarding probable demand for power etc., shows that the project may be made to pay. He also points out how with bad management the scheme might become a financial failure. A. H.

214. *Power-Transmission on Warships.* **G. W. Dickie.** (Elect. World, 30. pp. 699–700, 1897.)—This is a general discussion of the relative merits of water, compressed air, and electricity for use on warships, considered with reference to safety, economy, and comfort. The paper does not call for any detailed abstract. A. H.

215. *Electrical Plant of the Astoria Hotel.* (Elect. World, 30. pp. 751–754, 1897.)—The plant installed in this huge hotel has to supply power for over 2500 lamps, twenty-one electric elevators, and a large amount of auxiliary electrically-driven apparatus. There are six generators, four of which are 10-pole machines having an output of 250 kilowatts each, and two smaller 8-pole 100-kilowatt machines. The pressure of the current supplied to the adjoining Waldorf Hotel, which is under the same management, is raised by a special motor-driven booster. This machine is of 15 kilowatts capacity; its maximum E.M.F. is 5 volts, and its carrying capacity 3000 amperes. To provide for the efficient generation of so large a current at such a low voltage, the machine is provided with a commutator at each end of the armature. The two commutators were provided in order to provide for possible desire to boost two separate circuits; and two windings put on the armature ~~are~~ respectively connected to the two commutators. The machine is six-polar, and is direct-coupled to a six-pole motor, the booster field being excited by a

high-resistance winding connected across the bus-bars and controlled by a hand rheostat. The load being purely a lighting load, the hand regulation is sufficient. The commutator segments are of massive construction. The brushes are of a special construction, and consist of alternate copper and zinc leaves. A lever on either side enables all the brushes to be simultaneously raised. By means of this machine the pressure across the Waldorf Hotel feeders can be boosted 5 volts in addition to the 3 volts overcompounding of the main dynamos, the latter being sufficient for the shorter feeders of the Astoria Hotel.

W. G. R.

216. *Overhead Trolley Car for Ordinary Roads.* **G. Dary.** (Électricien, 15. pp. 1–2, 1898.)—The article contains an illustrated description of a motor car for use on ordinary roads, the power being supplied by two overhead conductors. The car is the invention of Messrs. W. S. Caffrey and H. B. Maxson, of Leno, Nevada, U.S.A. The side-poles supporting the conductors are 7 metres high and spaced 38 m. apart; the conductors are supported on insulators placed 4·8 metres above ground and 46 cm. apart. The two portions of the double trolley are connected by lattice-work resembling a sort of pantagraph, which gives them great flexibility. The flexible conductors coming down from the trolley to the car are coiled upon a drum, so arranged that when the car leaves the direct line of the trolley-wires the flexible conductors are uncoiled; the car may thus swerve as much as 60 metres from the line of poles, and can pass from side to side of the road without difficulty. The motor used is a 2 H.P. Westinghouse one. When loaded with 1130 kilogrammes, the car easily attains a speed of 15 miles an hour.

A. H.

217. *Patton Electric Tram Car.* (Elect. World, 30. pp. 640–641, 1897.)—The latest car made by Patton, who has adopted the Heilmann principle, is 16 feet in length. It carries a 25 H.P. gasoline engine, a six-pole 15-kilowatt Crocker-Wheeler dynamo, 200 cells of 200 ampere-hours capacity, and two 35 H.P. single-reduction motors. The battery is kept continually charged. No figures are given as to cost of running. W. R. C.

218. *Electric Operation of Steam Railroads.* **N. H. Heft.** (Elect. World, 30. pp. 485–487, 1897.)—An account is given of the results obtained upon the New York, New Haven, and Hartford Railroad Co.'s lines. The electrically-operated part consists of 16 miles on the third-rail system and 14 miles on the trolley system. The traffic to be dealt with is heavy, and

the stops are frequent. For example, on the Nantasket Beach line there are seventeen stations in 10·6 miles. As the service is half-hourly, the run has to be made in 26 minutes, leaving only 4 minutes at the terminus, which is almost impossible of accomplishment by steam locomotives. But this service is easily carried out by means of electricity, owing to the very large accelerating-power of the motors as compared with steam locomotives. On that account, a 60-ton train reaches a maximum speed of 31 miles per hour between the stations of Windermere and Allerton, although the distance is only 1800 feet. The distance of 9·3 miles between Hartford and New Britain is covered in from 18 to 20 minutes, at an average speed of 28 to 30 miles per hour: with a highly-geared motor a maximum speed of over 60 miles per hour has been reached.

The employment of electric traction enables open summer cars to be used, as there is no annoyance from smoke. The motor-cars at present in use are 32 tons in weight and equipped with two 125 H.P. motors. The trolley has not been found to be so satisfactory as a third rail, owing to the rapid destruction of trolley-wheels by arcing, and the difficulty in keeping the wheel on the line when making speed and taking curves. The third rail, on the other hand, is generally satisfactory, although contact-shoes have sometimes been carried away at crossings. The leakage from the third rail, which rests upon creosoted wooden blocks and is at a potential of 600 volts, has been found to be inconsiderable even when there is a large amount of water on the track. No inconvenience or danger has been experienced through shocks from the third rail. It has so far been found unnecessary to use copper feeders; the third rail is 100 lbs. per yard, and service-rails are 70 or 74 lbs., all bonded. The distance of transmission from New Britain to Hartford is 9·3 miles. There is an average loss of 26½ per cent. when two 52-ton trains are running. The cost of fuel is very low, as it is found possible to burn exclusively the half-consumed coal which is dumped from the extension front of the steam locomotives, no other fuel being employed. The author declines to make any comparison between the cost of electric and steam power for railway purposes, owing to the impossibility of doing so in a satisfactory manner. W. R. C.

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219. *Electric Power on Trunk-Line Railways.* **G. Forbes.** (Eng. Mag. 14. p. 1, 1897.)—Some particulars are given of the Niagara Falls Park and River Railway, the results at the Baltimore Tunnel, the Nantasket Beach Electric Railway, the Liverpool Overhead Railway, and the City and South London Railway. The running expenses, including repairs and renewals of carriages, of the two latter and of the Metropolitan District are as follows:—

	d.	Weight of train. T.	cwt.	lb.
City and South London	6·48 per train-mile.	37	7	0
Liverpool Overhead	3·84 „ „	38	5	2
Metropolitan District	11·76 „ „	157	10	0

It must be remembered that the weight of the Metropolitan train is very much heavier than those employed by the other two lines; but if the train-mileage of the latter were equal to the former, the cost of locomotive power of the latter would be reduced. An electric locomotive is capable of doing all that can be done by a steam locomotive, as shown by the results at the Baltimore Tunnel. There is no difficulty in the transmission. Where water-power is available, it is generally economical to transmit water-power hundreds of miles. It can be proved that the whole of the Scottish trunk lines might be worked electrically from water-power in that country. Taking coal at a dollar and a half per ton, electric locomotives would be cheaper than a steam railroad up to a distance of 40 or 50 miles from the power station: with water-power this distance increases on a busy line to several hundred miles. This economy is due to the fact that the best locomotives consume, even on trial tests, as much as 5 lbs. of coal per H.P. hour. Where electricity is to be worked in conjunction with steam upon an existing road, electric locomotives must of necessity be employed. But where electricity alone is to be used, the power should be applied to every axle of the train. By means of such a system the full advantages of electric traction are obtained, and the construction of the permanent way would be less costly.

W. R. C.

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220. *Rail Bonding.* **W. E. Harrington.** (Frank. Instit. Journ. 24. pp. 54–57, 1898.)—Experiments were made with various types of copper bond in combination with the Edison-Brown amalgam, which was used to improve the contact between the bond and the rail; in every case the resistance was diminished, in some instances very considerably. The resistance of the Bryan bond, consisting of a copper connection bolted to the rails, is generally much higher than that of the internal-contact type; but with amalgam in the joint it is lower than that of any bond except the Edison-Brown plastic bond. The internal bond is objectionable on account of the wearing effect of vibration and play of the rail-joint; the Bryan and Edison-Brown types are free from this defect.

The author concludes that the Edison-Brown bond is the best; the Standard bond, under the fish-plate, is very good, but difficult to place; the Bryan bond (amalgamated) is the best outside the fish-plate. Internal contact bonds should be stranded, and are improved by amalgamation. Iron-wire bonds are highly inefficient. The following table shows the resistances of various bonds :—

Kind of Bond.	Centre to Centre of Contacts.	Length of Bond.	Size of Contact.	B. & S. Gauge.	Number of Wires in Bond.	Ohms.	Per cent. Res. $=\frac{A}{B}$.
	inch.	inch.					
Joint only—no bond	36	—	—	—	—	·00071	—
Iron channel pin	45	48	$\frac{9}{16}$" pin.	0	1	·00049	69
Bryan—Iron wire	36	39	Plate $2\frac{3}{4}$" diam., 1" hole in it.	$\frac{1}{2}$"	2	·000286	40
Crown	30	36	$\frac{7}{8}$" head.	0000	1	·000247	34
Bryan—Iron wire, amalgamated..................	36	39	Plate $2\frac{3}{4}$" diam., 1" hole in it.	$\frac{1}{2}$"	2	·000224	31
Crown, amalgamated	30	36	$\frac{7}{8}$" head.	0000	1	·000185	26
Bryan—Copper wire	36	39	Plate $2\frac{3}{4}$" diam., 1" hole in it.	0000	2	·000175	24
Columbia	30	36	$\frac{7}{8}$" head.	0000	1	·000131	18
Columbia, amalgamated ...	30	36	$\frac{7}{8}$" head.	0000	1	·000126	17
Stranded crown	5	7	$\frac{7}{8}$" head.	0000	1	·0001	14
Plastic socket	$3\frac{1}{4}$	—	—	—	—	·000093	13
Bryan — Copper wire, amalgamated............	36	39	Plate $2\frac{3}{4}$" diam., 1" hole in it.	0000	2	·000071	9
Plastic cork	9	—	Surface $1\frac{1}{4}$" diam.	—	—	·00006	8
Solid rail—no joint	18	There were holes in web.				·000013	—

Tests made on Penna. Steel Co. 7-inch girder rail, No. 238. A=Resistance of bond. B=Resistance of joint only.

A. H. A.

221. *Use of Accumulators in Traction.* **C. Hewett.** (Elect. World, 30. pp. 483–485, 1897.)—The author considers the application of batteries, (1) in locomotives or cars, (2) at points of the line distant from the generating station, (3) in the generating station itself. It is improbable that batteries of the lead type will be largely used in accumulator cars, either simply or on the "mixed system," owing to the inherent defects in this kind of cell. Their use may, however, be advantageous at distant points of a line when the traffic becomes too heavy for the conductors. The Union Traction Company of Philadelphia have effected a considerable saving in capital expenditure by the adoption of this method instead of increasing the feeder system. The author recommends the use of batteries in the power-house enabling the engines to be worked at maximum efficiency, instead of running with an average load of two-thirds, as is usually the case. For this purpose the battery should have a capacity equal to one-third of the maximum output of the station. Under these conditions its efficiency will be high and deterioration low. W. R. C.

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222. *Accumulators for Rapid Charging.* **L. Epstein.** (Elect. Rev. 40. pp. 519–520, 1897.)—This is a critical examination of the accumulator system of electric traction advocated by M. Blanchon, who proposes to fix fairly heavy batteries permanently in the car, and of sufficient capacity for the day's total run, without, as a rule, drawing out more than two-thirds of the total capacity. This object is accomplished by a system of very rapid charging (12 to 20 minutes) at the terminus, the cells being charged not at constant current but at constant voltage. After criticising the various advantages claimed for this system, and comparing it with the usual one of exchanging batteries, the author concludes that probably a compromise between the two would give the best results. A. H.

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223. *Life and Candle-power of Incandescent Lamps.* (Elect. World, 30. pp. 763–765, 1897.)—The cost of lighting is very largely dependent on the progressive drop in candle-power which occurs with all types of lamps. Many central station managers consider that a lamp has passed its *useful life* when it has lost 20 per cent. of its initial candle-power. Poor regulation of voltage causes rapid deterioration of the lamps. The following table shows the decrease in life of standard 3·1 watt lamps due to increase of normal voltage:—

Per cent. of normal voltage...	100	101	102	103	104	104	106
Life factor........................	1	·818	·681	·662	·452	·374	·310

The author recommends the use of portable voltmeters for frequently determining the voltage at different points of the distributing network, and then either arranging the voltage to suit the lamps, or *vice versa.* Poor regulation is especially liable to occur in the case of alternating systems, on which the average efficiency of lamps is 4 watts per candle. The following table gives the variation in candle-power and efficiency of standard 3·1 watt lamps, due to variation of voltage :—

Per cent. of normal voltage...	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106
Per cent. of normal c.p.	53	57	61	65	69½	74	79	84	89	94½	100	106	112	118	124⅓	131½	138⅓
Efficiency in watts per candle.	4·68	4·46	4·26	4·1	3·92	3·76	3·6	3·45	3·34	3·22	3·1	2·99	2·9	2·8	2·7	2·62	2·54

The proper renewal of lamps is a matter of extreme importance from the point of view of economy. The author recommends free lamp renewals, and considers this method best for both the central station and the customer. Failing this, the next best plan would be to offer lamps at less than cost price, thus encouraging the consumer to renew his lamps at frequent intervals. The blackening of the bulbs is more often a supposed defect than a real one. A lamp may lose in candle-power and show but little blackening, and, on the other hand, the lamp may get quite black and lose very little of its initial candle-power. A. H.

224. *Quality of Incandescent Lamps.* **F. W. Willcox.** (Elect. World, 30. pp. 698–699, 1897.)—The object of this paper is to show the folly of using cheap lamps of low-grade quality. The most rational basis of comparison is to estimate the value of a lamp in terms of the candle-hours which it is capable of giving before the candle-power falls to say 80 per cent. of its initial value. On this basis a comparison is made between two lamps of American make, from which it appears that in order to obtain the same amount of light for a given expenditure of energy from the two kinds of lamps, the cheaper one would have to be renewed about four times as frequently as the more expensive one; an initial efficiency of 3·1 watts per candle being used. Another basis of comparison is next assumed, which is somewhat better adapted to practical working conditions than the first. It consists in assuming an average life of 600 hours for each type of lamp On this basis, a comparison of four types of lamps shows that the worst type furnishes only 66 per cent. of the candle-hours obtained with the best type, the intermediate ones giving 80 per cent. and 91 per cent. respectively. When the cost of energy is taken into account, these results show in a striking manner the utter insignificance of a small difference in first cost as compared with the corresponding difference in cost of a candle-hour. A. H.

225. *Tests of Alternating Enclosed Arc-Lamp.* (Elect. World, 30. pp. 695–696, 1897.)—The paper contains a description, illustrated by reproductions from photographs, of the appearance presented by the "Puritan" enclosed arc-lamp under various conditions of working, both normal and abnormal. The lamp takes

6 amperes at 65 volts, and the arc is found to behave like a non-inductive resistance. The normal length of arc is about ⅜″; the carbons used are ½″ Electra cored carbons; their ends remain flat, with fairly sharp edges, under normal working conditions. No data regarding the efficiency of the lamp are given. A. H.

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226. *Enclosed Arc-Lamp.* **W. H. Freedman, H. S. Burroughs,** and **J. Rapaport.** (Amer. Instit. Elect. Engin. 14. pp. 361–384, 1897.)—The authors tested a number of these lamps in order to study their characteristic features. Lamps of this type are placed singly across ordinary incandescent-lighting circuits, and are regulated to take approximately 80 volts across the arc, the rest of the potential being consumed in the regulating solenoid and extra resistance which are in series with one another. The standard current is 5 ampères, the arc being about $\frac{5}{16}$″ long, while the carbons burn nearly flat instead of taking the shape as in the case of the open arc, the arc wandering round the flat ends. The simplest form of friction clutch consists of a straight horizontal rod fastened to the end of the plunger of the solenoid, and having at each end an arm so pivoted that these two arms cross each other like a letter X. At each lower end of these arms is pivoted a friction piece of round or V-shaped surface that grasps the rod holding the upper carbon. Lifting the upper ends causes the lower ends to grip the rod. When the device falls far enough, it touches a stop and releases the carbon-holder. Another form of clutch consists of a series of steel balls resting on a grooved piece around the carbon-holder, and adapted to be pressed against the holder by a conical cup actuated by the plunger of the regulating solenoid. The brass rod carrying the upper carbon requires to be cleaned after each run (75–150 hours). The life of the carbons was found to be promoted by keeping the enclosing globe as small as possible. The positive carbon is consumed at the rate of about 0·05 in. per hour and the negative at half this rate. When burning at 80–85 V., the variation in the current is very considerably less than with an open arc. In one case the extra resistance was 6 ohms, that of the solenoid coil 1 ohm, normal voltage 115. The movable carbon enters the enclosed globe through a gas cap or check which obstructs the circulation of air as much as possible, but admits sufficient air to prevent excessive deposition of carbon on the globe. It consists generally of a plug fitting closly inside the top of the globe, and provided with a central tube through which the carbon passes freely, this tube having internal circumferential channels or grooves or slits opening into an intermediate air-chamber.

The distribution of the light is different to that obtained from an open arc. With the enclosed arc the maximum intensity is at an angle of 25° below the horizontal, and after a decrease another high value is obtained at 40°. For two clear glass globes, the watts per candle are about 0·5; with opal inner and clear outer, watts per candle 0·56 to 0·60; with both inner and outer opal, watts per candle 0·9 to 1, *i. e.* mean *hemispherical* candle-power. Also the efficiency from the use of a holophane globe was but little less than that of an ordinary clear globe (absorptions 9–13 per cent. and 5–8 per cent. respectively). The colour of the light was violet around the horizontal plane and white below it. If the arc be allowed to form too high up in the globe, deposit of carbon will take place. C. K. F.

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227. *Electric Meters.* **C. D. Haskins.** (Elect. World, 31. pp. 31–33, 1898.)—The author first advocates the use of small meters, preferring rather to lose an occasional meter by burning-out from extreme overload than to lose a considerable percentage of the revenue from long-sustained light loads. This light-load loss can also be obviated by putting the lamps most frequently in use on a separate circuit with a meter to itself.

The increase in the "friction-load" of the meter during use, which impairs the accuracy of the meter at light loads, is very fully discussed. The three chief factors influencing this are:—(1) The point of installation; (2) adjustment; (3) the accumulation of dirt. As regards (1) vibration should be avoided as much as possible, since it causes deformation of the pivots of the meter arbors and ultimate chipping of the jewels. In cases where this is unavoidable, the meters should be so constructed as to permit the easy renewal of both pivot and jewel. The point of least vibration is generally in or near the ground floor against a brick wall; points exposed to extremes of heat and cold, dust, dampness, fumes, should be avoided, as are kitchens, pantries, and the like by reason of the insects found in such places. As regards (2), the meters should be carefully levelled, since they are calibrated in a level position, and where vibration is unavoidable they should be mounted on sponge-rubber cushions. Meters for use with motors should be on the station side of the controlling switch: this prevents damage to the insulation of the fine wire potential-windings of the meter by expansion and contraction when the current is turned on and off, or by the kick or induction-current on interruption of the circuit. As regards (3), the average meter should be inspected and cleaned from two to three times annually. Dirt or dust should be removed by a pair of bellows; the condition of jewel tested by moving the pivot gently over the surface of the jewel-cup, when it should feel smooth and glass-like; poles of damping magnets, if any, brushed off with a thin piece of magnetised steel; commutator, if any, cleaned with cotton tape. The meters should *not* be oiled, as the merest film lasts for an indefinite period and too much ruins the light-load accuracy of a meter. Meters can be tested *in situ*, roughly, by putting a definite number of lamps on the meter, and determining the speed at which the meter-shaft rotates at this load, say by timing 1, 10, or 100 revolutions by a stop-watch; this method may be taken as being correct within 6 per cent. More correct results can be obtained by using an ammeter in series with the meter on the load side, with or without a voltmeter across the line on the station side of the meter. Or a definite load can be obtained by using a box containing say 6 calibrated incandescent lamps of various C.P.s, controlled by separate switches, in combination with a portable voltmeter.

The meter-men should only record the dial-indications by marking with a pencil the position of each hand on a printed diagram of the dial, the indications being afterwards translated by a competent person. To equalise the bills in the winter months, the readings may be taken on Nov. 5, Dec. 2, Jan. 1, Jan. 30, Feb. 27. A system of meter cards is also described in the original paper.

In the discussion on the above paper (Amer. Inst. Elect. Engin. 14. pp. 443-450, 1897), **Dr. Louis Bell** spoke mainly on the question of charging for alternating currents supplied to circuits having highly-inductive loads, so as to fairly compensate the supply company for the capacity of the machine used up by the wattless currents at light loads taken by motors having low power-factors. He suggested an ampère-meter acting in conjunction with the watt-meter to automatically take account of the maximum current. In reply to Dr. Perrine, **Mr. Haskins** said that, in his experience, a meter which will give accuracy, both at light load and also at high loads, will almost invariably be a good meter on intermittent loads. **Mr. Haskins**, in reply to Dr. Bell, considered it possible to produce a meter which will automatically vary its rate with the variation of the power factor. **Prof. Owens** suggested that this might be done by the addition of a "Wright-Demand" meter to the circuit containing a watt-meter. Mr. Haskins said that this would be imperfect in that it did not segregate idle from active currents, although it would otherwise be admirable. **Mr. Steinmetz** suggested that a part of the wattless currents could be charged for by replacing part of the non-inductive resistance of the potential coil of a recording watt-meter by reactance, say equal to 20 per cent. of the impedance of the potential coil, reducing the resistance correspondingly. With this the meter would read correctly at non-inductive load, but with a highly inductive load, of 20 per cent. power-factor or so—as the current of a motor running light—the meter will read just twice the power, or about one quarter of the wattless current. Mr. Steinmetz also pointed out the fact that some kinds of load, such as fan-motors and apparatus of high frequency for producing X-rays, broke up or changed the character of the current-wave so that it will pass through current-meters without being registered. This fact was confirmed by Mr. Haskins. C. K. F.

TELEGRAPHY AND TELEPHONY.

228. *Wireless Telegraphy.* **E. J. Houston** and **A. E. Kennelly.** (Elect. World, 31. pp. 17–18, 1898.)—This compilation is a short description of the various systems of Hertzian telegraphy.

R. A.

229. *Efficiency of Telephone Translators.* **L. Lefèvre.** (Ind. Élect. 7. pp. 11–14, 1898.)—The ratio of the watts supplied to the primary of a telephone translator to the corresponding watts in the secondary, is a measure of the efficiency of that instrument. This ratio has been determined by A. Reding for six kinds of translators, at different frequencies. Special attention is given to the material and form of the iron core. The required ratio is measured by two electro-dynamometers, one in the primary and the other in the secondary circuit. Current is supplied to the primary by an alternator at a frequency of 75 to 750, it does not exceed 8 milliamperes. The resistance in the secondary is varied from 0 to about 6000 ohms. A table gives the power lost in heat and the power lost in hysteresis for each case; a curve shows the efficiencies at different frequencies; and a figure gives the arrangement of apparatus. In order to reproduce, so far as possible, the actual case of an inter-urban telephone trunk-line system, Reding builds up an artificial circuit containing capacity and self-induction.

R. A.

230. *Telephone Tariff.* **X.** (Électricien, 14. pp. 389–390, 1897.)—An equable scale of charges between telephone companies and subscribers may be based either upon the number of "calls" per annum, or upon the total time that the subscriber is in circuit during the year. Theoretically, the scale ought also to be modified in a manner depending upon whether a "call" is to a subscriber in the same or in a different district. The working expenses of the company depend upon the number and duration of the "calls," and upon the number of distinct offices through which communication has to be established for a particular "call." If the subscribers are on different "exchanges" the switching operations occupy time and require an increased staff. The writer discusses the method of charging by annual tax supplemented by the number and duration of calls. Practically, the dual system of tariff leads to complication; choice has to be made between a tax founded upon the number of "calls" and a tax proportional to the time. Preference is given to a tariff based upon the number of "calls."

R. A.